Comparison of innovative hydroponic and conventional grafting techniques in Black pepper (*Piper nigrum* L.)

**Abstract**

The most devastating disease affecting black pepper (*Piper nigrum* L.) is *Phytophthora* foot rot against which none of the varieties is resistant. This difficulty has been overcome by the horticultural technique of grafting *P. nigrum* on the resistant root stock viz. *P. colubrinum*- a marshy wild relative of black pepper .The conventional technique of grafting of *P. nigrum* on *P. colubrinum* takes nine months to one year for developing a graft ready to be planted in the field and is labour and irrigation intensive. Innovative hydroponic soil-less methods based on the marshy adaptation of *P.colubrinum* and which require lesser labour and water have been compared with the conventional method. Instant grafting of the scion portion on the non - rooted root stock portion and rooting of the root stock hydroponically once the grafting procedure is completed has been found to save 6 months when compared to the conventional method in producing field-ready grafts with the highest graft recovery and water use efficiency.

**Key words**: Black pepper, graft, soil-less, *Piper colubrinum*, hydroponic

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**Introduction**

Black pepper (*Piper nigrum* L.), the historic 'King of Spices' has been used as spice since 4$^{th}$ century B.C. (Jibat and Alo 2021).The most devastating disease affecting black pepper is *Phytophthora* foot rot against which no variety has been found to be resistant (Hao et al. 2016). This difficulty has been overcome by the horticultural technique of grafting *P. nigrum* on root stocks of the wild related marshy species *Piper colubrinum* L. which is

resistant not only to *Phytophthora* but also to nematodes causing root knot in black pepper (Krishnamoorthy and Parthasarathy 2009). The technique of grafting of *P. nigrum* on *P. colubrinum* has been very successful and has been well standardized and well known (Vanaja et al. 2007). In the conventional method, two to three node cuttings of *P. colubrinum* of approximately 15 cm length are planted in poly bags of appropriate size to get them rooted. It takes approximately six to nine months for the cuttings of *P. colubrinum* to get rooted properly and reach a height of around 65 cm and appropriate girth of around 1 cm diameter at 45 cm height where cleft grafting is done in the popular method (Fig.1). Grafting at a height of around 50 cm is inevitable to avoid splashing of soil and debris that contain spores of *Phytophthora* and also to get more aerial roots growing from the root stock to the ground (Krishnamoorthy and Parthasarathy 2009).

Once grafting is completed, it takes another three months for the grafts to grow well with 5-6 well developed leaves so that they can be planted in the field. In total, it takes nine months to one year for developing a graft with a graft union height of 45 cm or higher which is ready to be planted in the field. The conventional method is a slow process which requires greater quantities of irrigation water and is labour intensive. It is required to find out faster and efficient alternatives to the conventional method with lesser irrigation water requirement. Besides this, the potting medium in poly bags often harbour pathogenic fungal spores and nematodes which unintentionally invade farmers' fields once these grafts are planted in their field. Transportation of grafted plants is cumbersome and costly due to the bulky nature of potting medium. Adaptation of *P.colubrinum* to marshy habitat which indicates its ability to root and thrive in water has never been exploited in graft production (Fig.2). Hence a trial was undertaken to compare the performance of soil- less hydroponic methods of grafting with the conventional and other possible alternatives.

**Materials and methods**

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The trial was undertaken at Pepper Research Station, Panniyoor, Kannur, Kerala during 2019-20.The experiment consisted of 5 treatments (Table 1).

Table 1.Treatments

| Sl.No. | Treatment | Description of treatment | Figure No. |
|---|---|---|---|
| 1 | T1 | 45 cm long *Piper colubrinum* cuttings planted in poly bags for rooting and further grafting | 3 |
| 2 | T2 | *P.nigrum* grafted on 45 cm long *P. colubrinum* and the basal nodes of the root stock submerged in water | 4 |
| 3 | T3 | Two node cuttings of *P.colubrinum* planted in poly bags (conventional method - control) | 5 |
| 4 | T4 | 45 cm long *P.colubrinum* cuttings put in water for further grafting | 6 |
| 5 | T5 | *P.nigrum* grafted on 45 cm long *P.colubrinum* and planted in potting medium in poly bag | 7 |

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The experimental design was completely randomised design (CRD) with 6 replications. Only orthotropic shoots of *P.colubrinum* were used as root stock and runners (basal adventitious shoots) of *P.nigrum* variety 'Panniyur 1' were used as scion in the experiment. The size of the poly bags used was 20 cm x 15 cm and potting medium was 1:1:1 mixture of sand, soil and dry farm yard manure. Irrigation water required to bring the potting medium in poly bags to saturation point was calculated as per Imakumbili 2019. Two hundred millilitres of water

once daily was applied to each poly bag to bring it to saturation. In hydroponic treatments, 500 ml clean tap water was taken in 1 litre containers and only the basal two nodes of the root stock were submerged in water. Water in the container was replaced with fresh tap water once in 10 days. All the treatments were kept in a closed poly house nursery, under natural day light. The temperature inside the poly house seasonally varied from 28°C to 35°C and relative humidity varied from 85% to 98%. Data was recorded on days to bud activation on root stock, days to root initiation, number of roots on root stock 60 days after planting/submergence, length of roots on root stock 60 days after planting/submergence (cm), days taken for grafting on root stock, days to get field- ready grafted plants, water requirement per field- ready graft (L), per cent loss of grafted plants and water use efficiency. Days taken for grafting on rootstock was recorded as the number of days taken by *P.colubrinum* cutting to grow and reach a height of around 65 cm and appropriate girth of around 1 cm diameter at 45 cm height where cleft grafting could be done properly .Grafts with minimum graft union height of 45 cm and with 5-6 well developed leaves on the scion were considered to be ready to be planted in the field. Water requirement per graft was calculated by dividing the total volume of irrigation water applied to the treatments by the number of replications in case of treatments where root stocks were planted in poly bags. Water requirement per graft in case of hydroponic treatments was calculated as the total volume of water to be kept in containers for keeping the lower two nodes of root stock submerged for all the replicates divided by the number of replications. For calculating per cent loss of grafted plants, wilted and dried up scion was taken as the indication for loss of the graft even though the rootstock portion was intact. Water use efficiency (%) was calculated as the total number of successful grafts recovered per litre of irrigation water applied. Statistical analysis was done as per Gomez and Gomez, 1984.

**Results and discussion**

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Days to bud activation on root stock ranged from 7.5 to 15 (Table 2).

Table 2.Growth parameters and recovery of grafts under different systems of grafting in black pepper

| Treatments | Days to bud activation on root stock | Days to root initiation | Number of roots on root stock 60 days after planting/submergence | Length of roots on root stock 60 days after planting/submergence(cm) | Days taken for grafting | Days to bud activation on scion after grafting | Days to field ready grafted plants | Water requirement per field ready graft(L) | Per cent loss of grafts | Water use efficiency (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 7.5[c] | 13.7[a] | 7.0[a] | 7.3[c] | 85.8[b] | 17.5[b] | 184.5[b] | 36.9 | 22.8(28.6)*[b] | 12.6 |
| T2 | 9.3[c] | 5.7[c] | 7.3[a] | 16.1[a] | - | 12.5[c] | 95.0[d] | 4.75 | 6.8(14.9)[d] | 117.7 |
| T3 | 9.5[c] | 13.3[ab] | 3.5[c] | 7.7[c] | 206.7[a] | 17.7[b] | 287.3[a] | 57.46 | 15.3(22.9)[c] | 8.8 |
| T4 | 11.8[b] | 11.8[b] | 5.8[b] | 12.3[b] | 49.2[c] | 13.8[c] | 124.2[c] | 6.21 | 12.2(20. | 84.8 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 4)[c] | |
| T5 | 15[a] | 14.5[a] | 7.0[a] | 4.6[d] | - | 19.8[a] | - | - | 94.0 (76.4)[a] | - |
| CD(5%) | 2.2 | 1.6 | 1.1 | 0.7 | 12.8 | 1.9 | 6 | - | 3.4 | - |
| CV | 17.5 | 11.5 | 14.4 | 6.3 | 9.1 | 10.1 | 2.9 | - | 8.9 | - |

*Figures in parantheses indicate transformed values

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The earliest bud activation on root stock was recorded for T2 ( *P.nigrum* grafted on 45 cm long *P. colubrinum* and the root stock put in water) which was on par with T1 and T3 and the last to record bud activation was T5 (*P.nigrum* grafted on 45 cm long *P.colubrinum* and planted in poly bag).T2 recorded significant earliness for root initiation on root stock while the last to root was T5 which was on par with T1.Root stocks planted in potting mixture generally took more time for root initiation. The highest number and length of roots 60 days after planting/submergence was recorded for T2 (Fig.8 and 9).This trait can be supposed to impart greater anchorage once planted in soil and greater nutrient absorption ability to T2 during the early months of graft union. Fourty five centimetre long *P.colubrinum* cutting put in water (T4) became ready for grafting around one month earlier than T1 even though the earliest bud initiation on root stock was observed in T1. This could be attributed to the early

root initiation and better root length in T4. Control (T3) took the highest number of days (206.7) for producing sufficient growth for getting 45 cm long root stock. Instant grafting was possible for T2 and T5 only. Bud activation on scion after grafting was the earliest in T2 which was on par with T4.T2 produced field- ready grafted plants in 95 days while T3(control) took 287.3 days and T4 took 124.2 days. Irrigation water requirement per field-ready graft was the lowest for T2 (4.75L) and the highest for the conventional method (57.46 L).Though instant grafting was possible in T2 and T5, percent loss of grafts was the highest and the most significant in T5.This could be due to the failure of non-rooted root stock to supply water to the scion and consequent wilting of scion. Per cent loss of grafts was the least for T2. In general, early bud activation on scion and lesser per cent loss of grafts were observed when the basal nodes of root stocks were put in water rather than anchored in potting mixture. Water use efficiency was the highest for T2 (117.7%) and the least for the conventional method (8.8%).

Soil -less method of grafting *P.nigrum* on *P.colubrinum* and keeping the lower nodes of root stock in water was found to produce the highest number of field- ready grafted plants in the minimum time. This method has the additional advantages of high water use efficiency, freedom from daily irrigation and, thus saving irrigation water and labour. Inadequate water availability and labour scarcity have been indicated as two constraints faced by black pepper farmers (Krishnamoorthy and Parthasarathy, 2009) and this soil- less grafting method has great relevance under such challenges.

**Conclusion**

Instant grafting of *P.nigrum* on *P.colubrinum* root stock of sufficient length followed by submerging the basal two nodes of the root stock in water was found to produce the highest

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number of grafts in much shorter time than in the conventional method. This soil-less, water use efficient method also saves irrigation water and labour .

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Figures

**Fig.1** Cleft grafting in *P.nigrum*

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**Fig.2** Profuse root growth in *P.colubrinum* under water

**Fig.3** T1

**Fig.4** T2

**Fig.5** T3

**Fig.6** T4

**Fig.7** T5

**Fig.8** Treatments 60 days after planting or submergence

**Fig.9** T2 Sixty days after grafting

Fig.1 Cleft grafting in P.nigrum

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Fig.2 Profuse root growth in P.colubrinum under water


Fig.3 T1

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Fig.4 T2

Fig.5 T3

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Fig.6 T4


Fig.7 T5

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Fig.8 Treatments 60 days after planting or submergence

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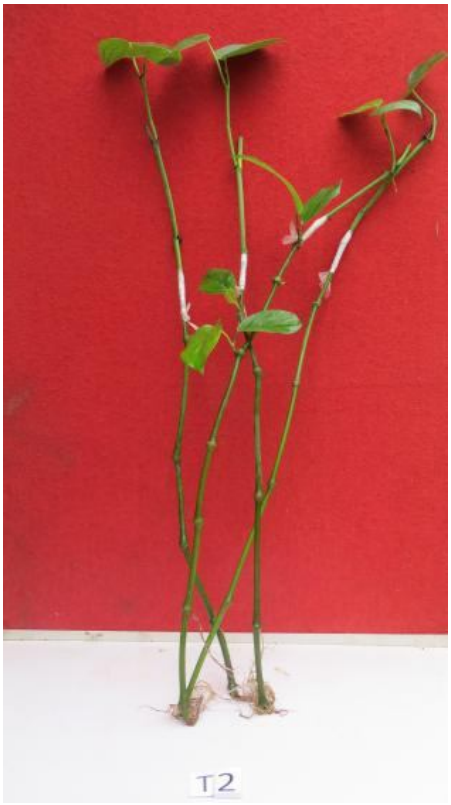


Fig.9 T2 Sixty days after grafting

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