Grafting to improve bitter melon (*Mormodica charantia* L.) productivity and fruit quality

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STATEMENT OF ORIGINALITY

This thesis contains no material which previously has been accepted for the award of any other degree or diploma in any universities or tertiary institution. Further, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference has been made in the text.

Thanh Son Le

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ABSTRACT

Bitter melon (*Momordica charantia* L.) is a tropical and sub-tropical plant, which is widely cultivated in Asia and Africa. Bitter melon fruit has a remarkably long history of use as food and traditional medicine because it has high nutritional value and bioactive compounds. The demand for bitter melon is increasing but its cultivation is facing some challenges, such as low yielding varieties, soil-borne diseases and limited growth in harsh conditions. Traditional cultivation and/or the use of indigenous varieties are the main causes of low productivity compared to the commercial high-yielding varieties. Moreover, soil-borne diseases can also lead to yield loss. Pythium root rot and Fusarium wilt are common diseases that cause the death of seedlings and mature plants. Bitter melon performs poorly in unfavourable conditions, such as saline soil and cold temperatures. Unfortunately, bitter melon is increasingly being produced in sub-optimal conditions, including high salinity, and this is particularly the case in Vietnam. Therefore, it is important to improve the productivity of local varieties that can be tolerant to salinity and resistance to diseases.

The aim of this study was to improve the productivity and performance of a Vietnamese bitter melon variety (VINO 12) by grafting it on different rootstocks that may improve productivity, increase soil-borne disease resistance and enable it to be grown under saline conditions. In this study, rootstock seedlings were exposed to salinity and *Pythium aphanidermatum* treatments to evaluate their resilience to these stresses. The three rootstocks used in this study were pumpkin (*Cucurbita maxima*) varieties including Queensland Blue (Qb), Sampson (Sp) and Ringer (Rg). These were chosen because they are less affected by soil-borne diseases in Australia. Initially, the survival rate of the three rootstock and bitter melon scion seedlings was determined based on resistance to *Pythium aphanidermatum* and salinity. Then, the three rootstocks were used for grafting bitter melon and grown in subsequent experiments. Two grafting methods were applied, the single leaf splice (SLS) method and the tongue approach (TA) method. The most successful grafting method (SLS) was used in subsequent experiments. The grafted bitter melon plants were grown indoors and outdoors for two subsequent seasons (off season in 2016 and main season in 2017) under saline and non-saline conditions. The growth, fruit yield and fruit quality of the grafted plants grown under the different conditions were assessed to compare with controls (ungrafted and self-grafted) grown under the same conditions.

When tested with *Pythium aphanidermatum*, the Sp rootstock had the lowest rate of seedling death (29%) while Rg was second best (44%), bitter melon was the second worst (63%) and Qb was the worst (96%). All three rootstock and the scion seedlings could grow under saline conditions (16 dSm^{-1}) with survival rates of 60% and above. However, at 26 dSm^{-1}, the Sp rootstock seedlings had the highest survival rate (76%) and the Qb rootstock was the second best (52%) while the Rg rootstock and the bitter melon seedlings did not survive (0%).

The SLS grafting method was more successful than the TA method. The SLS method had a success rate of 81-91% for all three rootstocks, whereas the TA method only achieved a 60-76% success rate. The SLS method was then applied for grafting with the three rootstocks for growing in the subsequent experiments.

All three rootstocks and saline conditions at 16 dSm^{-1} did not significantly affect the development of the grafted plants grown indoors and outdoors for both main seasons and off seasons. However, the number of female flowers, fruits and fruit yield was influenced by the three rootstocks. In general, the grafted plants had more female flowers and fruits as well as a higher fruit yield than those of the control. Among the three rootstocks, the Rg and Sp rootstocks were found to have the highest fruit yield, which were from 45-53% and 39-64% higher for Rg and from 33-71% and 10-31% higher for Sp than that of the control plants under saline and non-saline conditions, respectively.

In terms of fruit quality, there was no consistent effect of the rootstocks and salinity. However, the Qb rootstock gave the best fruit quality under some limited and specific growing conditions. The main observation was that bitter melon fruit grown during the main season 2017 had higher TSC, TPC and antioxidant capacity than the fruits grown during the off season 2016. Of these, the fruits grown outdoor during the main season 2017 also had the highest TSC, TPC and antioxidant capacity. The values were 2-3 times higher for TSC, 9-10 times higher for TPC and 5-20 times higher for antioxidant activities for the plants grown outdoor during the main season 2017 than for those grown indoor.

In conclusion, the Sp rootstock seedlings had the highest resistance to *Pythium aphanidermatum* and salinity. The SLS method was superior for grafting bitter melon to rootstocks and all three rootstocks were suitable for grafting with the Vietnamese VINO 12 bitter melon scion. Among the three rootstocks, the Rg and Sp rootstocks were found to give the highest bitter melon fruit yield under both saline and non-saline conditions. However, there was no consistent effect of the rootstocks and salinity on the fruit quality although the Qb

rootstock gave the best fruit quality under some limited and specific growing conditions. Furthermore, growing the bitter melons outside during the summer season caused the biggest increase by far in the fruit TSC, TPC and antioxidant capacity. Therefore, the Sp rootstock is recommended to be used as rootstock for resistance to Pythium and salinity, while Rg and Qb are suggested to be used as rootstock for fruit yield and fruit quality, respectively, under select conditions.

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LIST OF ABBREVIATIONS, SCIENTIFIC SYMBOLS AND UNITS OF MEASUREMENT

Abbreviations

a*	Red/green coordinate
b*	Yellow/blue coordinate
C	Chroma
CO_2	Carbon dioxide
CRD	Complete randomized design
DAP	Days after pollinating
DAS	Days after sowing
DW	Dry weight
EC	Electrical conductivity
ECe	Electrical conductivity of the soil saturation extract
Fig	Figure
FW	Fresh weight
GA3	Gibbrellic acid
HCl	Hydrochloric acid
Ho	Hue angle
H_2SO_4	Sulphuric acid
Kgf	Kilograms force
$K_2S_2O_8$	Potassium persulfate
L	Lightness
MeOH	Methanol
mL	Millilitre
mm	Millimetre
mPDA	Modified Potato Dextrose Agar
NAA	α- Naphthalene acetic acid
NaCl	Natri clorua
NaOCl	Javel or Hypochlorite
NaOH	Sodium hydroxide
Na_2CO_3	Soda or Sodium carbonate

NPK	Nitrogen (N), phosphorus (P), and potassium (K)
PA	*Pythium aphanidermatum*
PCA	Potato carrot agar
RHD	Rootstock hypocotyls diameter
RH	Relative humidity
SE	Standard error
SD	Standard deviation
SHD	Scion hypocotyls diameter
SLS	Single leaf splice
TA	Tongue approach grafting method
WA	Water agar

Units of measurement

%	Percentage
°C	Degree Celsius
dS/m (dSm^{-1})	Siemens per meter
g	Gram
g/L	Gram per litre
kg	Kilogram
cm	Centimeter
$g\ g^{-1}$	Gram per gram
$mg\ g^{-1}$	Milligram per gram
mm	Millimeter
nm	Nanometer
µl	Microliter
µm	Micromole
v/v	Volume per volume

COMMON AND SCIENTIFIC NAMES OF CROPS USED AND MENTIONED IN THIS STUDY

Common name	**Scientific name**
Bitter melon, bitter gourd	*Momordica charantia* L.
Bitter melon (small fruit)	*Momordica charantia* L. var. *minima* Williams et Ng.
Bitter melon (large fruit)	*M. charantia* L. var. *maxima* Williams et Ng.
Bottle gourd	*Lagenaria siceraria*
Cucumber	*Cucumis melo* L. var. *cantaloupensis*
Figleaf gourd	*Cucurbita ficifolia*
Luffa	*Luffa cylindrica*
Luffa	*Luffa aegyptiaca*
Melon	*Cucumis melo* L.
Muskmelon	*Cucumis melo* L. var. *reticulatus*
Rockmelon	*Cucumis melo* L.
Oriental melon	*Benincasa hispida*
Pumpkin	*Cucurbita maxima*
Pumpkin	*Cucurbita moschata*
Pumpkin, summer squash	*Cucurbita pepo*
Squash	*Cucurbita spp.*
Watermelon	*Citrullus lanatus*
Winter melon	*Cucumis melo* var. *inodorus*
Common bean	*Phaseolus vulgaris* L.
Eggplant	*Solanum melongena* L.
Red-pepper	*Capsicum annuum* L.
Peach fruits	*Prunus persica* (L.) Batsch
Quinoa	*Chenopodium quinoa* Willd.
Tomato	*Lycopersicon esculentum* Mill.
Tomato	*Solanum lycopersicum* L.