The Effect of vernalization and simulated ‘cold’ conditioning of garlic (*Allium sativum*) under tropical conditions.

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Introduction

- Garlic (*Allium sativum*) is used as condiments, spices, seasonings, or flavoring as well as for its medicinal value (Ade-Ademilua *et al.* 2009).
- It is a temperate crop where the ontogeny and bulb production is influenced by a genotype-environment interaction of temperature and photoperiod (Takagi, 1990).
Introduction

- Some varieties have adapted to the more southern latitudes with some degree of bulb formation under more sub-tropical conditions.
- There are some varieties (California Early and Late) that are prolific, but a period of cold exposure (6 to 8 weeks / < 60°C) is needed for proper bulbing and clove development.
Introduction

- Photoperiod (>16 hr darkness) interacts with temperature (0°C and 5°C) so that cloves held in cold storage will bulb quickly when planted.

- *Hardneck* garlic requires vernalization (6 to 10°C for 6-12 weeks) before planting as it stimulates sprouting and bulbing.

- The emergence of the sprout is subjected to breaking of dormancy, and bulb initiation is promoted by exposure of cloves to environmental or cold conditioning (Kamenetsky *et al.*, 2004).
Introduction

- Bulbs exposed before planting to 0.0 to 10°C / 2 months have accelerated growth as the low temperatures modify the hormonal balance (Bridgemohan and Ramoutar, 2018).

- The conditioning (5°C / 5 weeks) accelerates the crop cycle, reduces plant height and increases the synthesis of phenolic acids due to the stress of low temperature (Guevara-Figueroa et al., 2015).
In the tropics where the day-length is more or less even, and the lowest night temperature occurs in the month on January and rarely reaches 18-20°C, and soil temperature in excess of 34°C, it is a challenge to get garlic bulb formation beyond the vegetative growth (Bridgemohan and Ramoutar, 2018).
Objectives

- To investigate the effects of various temperatures for Vernalization before planting.
- To assess the effects of stimulated cold conditioning in the field on growth, development and bulb formation.
Material and Method

- This study was conducted during the period 2017 to 2018 at the Waterloo Research Campus, University of Trinidad and Tobago using a semi protected greenhouse covered with saran white (50% shade).

- The variety used was the popular and locally available (imported) Chinese Softneck garlic var Silverskin.

- The whole head was used in the study, and only the germinated cloves or “seeds” were subjected to any further experimentation.
Material and Method

The trial laid was out as Randomized Block Design (RBD) with 3 simulated cold treatments X 5 vernalization temperatures X 2 chilling treatment with a minimum of 48 plants per treatment. Environmental variables monitored throughout the experiments included:

- day length,
- soil and air temperatures,
- crop emergence (%),
- plant growth (Plumule / radicle length) and
- reproductive development (days to head formation, harvest, and yield) recorded.
Material and method

- The ‘seeds’ were vernalized with the cold treatments before planting at -28.8, 0.0, 3.7, 5.0, and 23.0°C, under dark conditions for 42 to 45 Days.

- The garlic heads were then removed and placed in a petri dish with moistened filter paper in the open to encourage sprouting or germination.

- The emergence of the plumule beyond 2.6 cm was recorded as sprouting (%) and observed for the different treatments.
Material and method

- Transplanting: 8 days after vernalisation.
- Soil type: sandy loam.
- Fertilizer application: 10g 24:12:24 per plant at 10 and 40 days after transplanting.
- Pest and disease control: a foliar application of Cypermethrin, 20-30ml per 20 litre as a protective measure. No diseases was observed.
- Weeds were manually removed.
Material and method

- The simulated ‘cold ‘conditioning treatments were different types of Mulches [M] viz: coconut coir, sawdust, and control, and with/or without a ‘Soil Chilling’ treatment.

- The soil chilling treatment was the application of ice–chilled water (200ml) every 3 days for a period of 60 days or until first bulb formation.
Results and Discussion

1. The effects of vernalisation temperatures.
   - The garlic seeds were removed from the various vernalization temperature (VT) after 42 days.
   - After 3 days in the open, all the treatments had sprouted except the zero and sub-zero (-28°C) treatments which did not break the dormancy of the seeds.
   - VT between 3.7°C to 23°C displayed a decreasing line of response in germination with the lower VT of 3.7°C and 5°C with 100% plumule and radicle emergence.
   - At the end of 7 days of vernalization (DAV), the plumule and radicle were in excess of 1 cm.
## Results and Discussion

Table 1. The effect of vernalisation on garlic emergence

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>% Plumule Emergence</th>
<th>Plumule Length (cm)</th>
<th>% Radicle Emergence</th>
<th>Radicle Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>29</td>
<td>0.32</td>
<td>97</td>
<td>1.15</td>
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<tr>
<td>5</td>
<td>100</td>
<td>0.96</td>
<td>100</td>
<td>1.29</td>
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<td>3.7</td>
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<td>1.61</td>
<td>100</td>
<td>1.02</td>
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<tr>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>-28.8</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Results and Discussion

Fig 1. The effect of temperature on plumule and radicle emergence
Results and Discussion

Fig 2. The effect of temperature on plumule and radicle length
Results and Discussion

2. **Stimulated cold conditioning**
   - The crop growth was monitored from transplanting to 160 days after planting (DAP) and dry matter accumulation determined.
   - There was no effect of the VT and the Mulch X Soil conditioning temperatures (MT) on the plant height \( H \), but DAP (D) and MT significantly increased the leaf number \( \text{Ln} \) until harvest.
Results and Discussion

- Regardless of VT or MT, the leaf length [LC] increased with the growing period. Similarly, leaf dry matter [g/pl] significantly increased with the mulch x cold treatment (MT) which is shown as S+M+CC where:
  
  $S = \text{stimulating treatment}$  
  
  $M = \text{mulch treatment}$  
  
  $CC = \text{cold conditioning}$
Results and Discussion

- The shoot length [SC] was not influenced by MT, but increased with VT, whilst neither VT nor MT had any effect on root length [RC].
- There were no apparent variations between the type of mulch material used.
- The shoot dry weight [SDW] increased over the growing period (D) and was significantly increased by the S+M+CC treatment.
Results and Discussion

- A similar trend was observed in the root dry weight [RDW], the simulated cold treatment produced the highest bulb weight over time (D) and increased with decreasing VT.

- The VT at 3.7°C on the S+M+CC media X simulated ‘cold’ conditioning was the only treatment that produced garlic bulb which was able to partition the accumulated assimilates into individual garlic cloves.
Table 2. The effect of varying Vernalization temperatures on garlic dry matter accumulation grown on different media (M) and cold condition (CC) treatment at 155 days after emergence.
Conclusion

- The study has confirmed that vernalization at 3.7°C to 5°C for 42 days, and transplanted using simulated ‘cold’ conditioning has the potential to produce garlic bulbs with acceptable clove number and size under tropical conditions in the shade.

- Garlic displays "biological elasticity" or the ability to acclimate to temperature and photoperiodic factors over time under tropical conditions.
Conclusion

- Whilst low temperatures are associated with many structural, physiological, and biochemical changes within plant cells, the role of plant breeding and selection has an integral role in altering gene expression patterns (Kosmala et al., 2009).

- The knowledge on the response of ‘cold’ conditioning at the functional and biochemical levels in garlic is very limited and this preliminary study can pave the way for the production of the crop in areas of high elevation in the tropical Caribbean.
Acknowledgements

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References


