Effect of plastic mulch, drip irrigation and fertigation on vegetative growth and chemical attributes of guava in Tarai region

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Abstract

The present study was carried out in an experimental field at horticulture research centre Patharchatta, department of horticulture, G. B. P. U. A & T Pantnagar Uttarakhand during the year 2017 and 2018, respectively. The experiment was conducted under randomized block design with 19 treatments and 4 replications in which irrigation and fertilizers were provided through drip system. There were different levels of drip irrigation (100, 80 and 60 per cent based on estimated irrigation water requirement) and fertigation (100, 80 and 60 percent of recommended dose fertilizer NPK) along with silver-black plastic mulch to standardize an appropriate level of irrigation as well as fertigation for proper growth and development of guava cv VNR Bihi in Tarai region. The results depicted that the treatment combination MDI:Ft i.e. mulch application with drip irrigation at 80 per cent level and fertigation at 100 per cent recommended dose of fertilizer (225: 165: 150g NPK) was most superior with maximum plant height, plant girth, T.S.S. and acidity during the year 2017 as well as 2018, respectively.

Keywords: Plastic mulch, fertigation on vegetative, guava

Introduction

Guava (Psidium guajava L.) being tropical and subtropical fruit crop in nature is considered the fifth most important fruit in area and production. It is also known as “apple of tropics”. Guava is hardy, prolific bearer and remunerative fruit. It is fairly cold-hardy and can survive as low as 5 °C (41 °F) for short periods of time at night (Wei 2008) [20]. Guava seems doing equally well on heavy clay, marl, light sand, gravel bars near streams, or on limestone and tolerating a pH range from 4.5 to 9.4. It is also known somewhat as a salt-resistant a crop (Singh et al., 2017). Nowadays water table in Tarai region of Uttarakhand has also shown a declining trend there by decreasing the availability of water for irrigation purposes. The limited availability of irrigation water during the dry season is a major constraint in increasing area under guava cultivation. Even the unscientific water management practices coupled with lack of proper water saving technologies can lead to the reduction in crop yield. Judicious application of water and plant nutrients in guava is prerequisite to achieve the targeted growth, yield and quality of fruits (Singh and Singh, 2007) [14]. Drip irrigation provides an effective and cost efficient way to supply water and nutrients to crops (Bar-Yosef, 1999) [3]. Drip irrigation with fertigation offers the possibility of precisely placing water and nutrients in the plant root zone at the timing and frequency needed to enhance the agricultural production and water use efficiency. It is established that drip irrigation and plastic mulching improves the fruit quality in many other crops (Singh et al., 2009) [15]. Many workers have reported that there is 50 to 70 percent saving in irrigation water and 10 to 70 percent increase in yield of fruit and vegetable crops through drip irrigation (Cetin et al., 2004; Ramniwas et al., 2012; Singh et al., 2006) [14, 8, 13]. As the global water consumption is doubling every 20 years (Vorosmarty et al., 2000) [19] and projected increase in food demand will have to be met by irrigation. Appropriate scheduling of irrigation increases the water use efficiency along with water saving for other purposes. The surface irrigation system is most common method of irrigation. Fertigation (application of fertilizer solution
with drip irrigation) has the potential to ensure that the right
combination of water and nutrient is available at the root
zone. Fertigation saves fertilizer as it permits applying
fertilizer in small quantities at a time matching with the plants
nutrient need. Mulching has been found beneficial in
improving physical and biological health of soil (Garg et al.,
2007) [3]. The response of guava to the combined effect of
drip with different levels of irrigation in conjunction with
polyethylene mulch and their economic feasibility are not
well known. The water requirement through drip irrigation
has not been studied for guava in Tarai region, therefore an
experiment was conducted to evaluate optimum irrigation
level with fertigation dose and plastic mulching to improve
the vegetative characteristics of plant as well as physical and
biochemical attributes of guava fruit.

Material and Methods

The experiment was executed at Horticulture Research
Center, Patharchatta, GBPUA & T, Pantnagar, located in
foothills of Himalayas at an altitude of 243.84 m above mean
sea level and lies between 29°N latitude and 79.3°E longitude
during the year 2017 and 2018. The experimental site had
typically humid sub-tropical type of climate. The soil of the
research field was silty loam in texture with a pH of 6.17 and
an electrical conductivity of 0.19 dSm⁻¹. The spacing between
the plants in the experimental field was 5m × 3m. The
experiment included eighteen treatment combinations with
one control (conventional system of irrigation with soil
application of recommended dose of fertilizers) and was laid
out in randomized block design. There were twelve treatment
combinations with one control (surface irrigation with soil
application of recommended dose of fertilizers). The different
treatment combinations comprised of three levels of drip
irrigation (100%, 80% and 60% of estimated irrigation water
requirement) as well as fertigation with three different levels
of recommended doses of fertilizers (100%, 80% and 60%
RDF) in combination with and without silver-black plastic
mulch. The recommended dose of fertilizers for three year old
guava tree was 225g/plant N: 195g/plant P: 150 g/plant K.
there were 4 replication for each treatment therefore 76 plants
were selected for the experiment. Also, every plant row was
provided with one lateral drip line having 4 emitters (of 4 l/hr
discharge rate) per plant. The operating pressure of the drip
irrigation system was maintained at 1.2 kg/cm².

During the present study, the vegetative character of guava
plant, physical and bio-chemical quality attributes of fruits
viz., plant height, plant girth, fruit firmness, T.S.S. and acidity
were investigated. The height of tree was measured from the
bottom to the top of a tree with the help of a measuring pole
and expressed in metres, once before the start of experiment
and again after the termination of the experiment during the
years 2017 and 2018. The increase in tree height was
expressed in per cent (%) as calculated by dividing the
difference in plant height with the initial plant height. Before
the commencement of the experiment, the stem of the each
tree was marked at a point 15 cm above the ground level. The
stem girth was measured with a measuring tape before the
commencement of experiment and after the termination of
experiment during the years 2017 and 2018. The values of
increase in trunk girth were expressed in per cent (%). Total
soluble solid content was determined from the juice of four
randomly selected fruits per plant. The extracted juice was
stirred properly. A drop of this juice was placed on the prism
of Erma Hand refractometer and degree brix of total soluble
solids was obtained from direct reading (AOAC, 1990) [1].
The titratable acidity (per cent) was determined through the
titrination method as mentioned by (Ranganna, 1986).

Results

Data related to plant height (Table 1) revealed significant
differences among percent increase in the plant height under
different treatment combinations in both the years. During
both the years 2017 and 2018, the increase in plant height
39.39 and 38.75 per cent was found significantly maximum
under MDI F₁ (mulch +80% DI +100% RDF) and minimum
increase in height 21.58 and 23.75 per cent was under control
(conventional irrigation with recommended fertilizer dose).
The observations on plant height under different treatments
excluding control were also statistically analyzed using three
factorial randomized block design. The results revealed that
there was a significant difference in the main effect of mulch
and fertigation during both the years of experiment (2017 and
2018) but in case of drip irrigation there was a non-significant
difference. Plants which were mulched showed maximum
increase in height (36.45 and 34.31 per cent) as compared to
those which were kept without mulch. Likewise among the
different levels of recommended dose of fertilizers (RDF),
100 per cent RDF shower maximum (36.65 and 35.00 per
cent) increase in plant height during the both years of study.
On the other hand the impact of drip irrigation solely had a
non-significant effect on the per cent increase in plant height
during the entire course of study. Increase in plant height
might be attributed to the fact that constant and continuous
supply of nutrients to the active root zone might have caused
minimum time lag between application and uptake of
nutrients resulting in better cell turidity which had led to cell
enlargement and better cell wall development thus resulting in
better plant vigour (Viers, 1972) [18]. The availability of N and
K in the root zone through fertigation might have induced
more plant vigour (Raskar, 2000). Similarly, Ramiyas et al.
(2012) [8] found that in guava plants the maximum plant height
was under 100 per cent application of recommended dose of
fertilizers also, the interaction effect of irrigation and
fertigation levels on plant height was non-significant. Also
Khan et al. (2013) [9] revealed that interaction effect of mulch,
fertigation and drip irrigation was found non-significant on
plant height of guava cv. Allahabad Safeda. Among the
different treatment combinations, the higher plant girth (50.29
per cent) was found under MDI F₂ during the year 2017. In the
following year (2018), the treatment combination MI F₁
exhibited highest plant girth (32.64 per cent). On the other
hand, the lowest (22.01 per cent and 25.05 per cent) plant
girth were obtained under control, in 2017 and 2018
respectively (Table 2). Further, the integrated effect of mulch
× drip irrigation, drip irrigation × fertigation and fertigation ×
mulch was almost non-significant during both the years of
study. Also the sole effect of drip irrigation gave non-
significant results in the entire course of study. The individual
effect of mulch and fertigation also revealed significant
variations as mulched plans showed maximum increase in
plant girth as compared to the UN mulched plants during the
both years of study also the higher dose of recommended dose
of fertilizer was able to augment maximum plant girth during
the year 2017 and 2018, respectively. According to Shirgure
et al. (2001) [12], total nitrogen and potassium uptake was
appreciable higher with increasing nitrogen and potassium
rate with more frequent than with less frequent fertigation. No
significant difference was revealed for the stem girth of
pomegranate cv. Ganesh subjected to varied levels of drip
irrigation (Sulochanamma et al., 2005) [17]. Similarly Khan et
al. (2013) [6] revealed that interaction effects of mulch, fertigation and drip irrigation were found non-significant on plant girth of guava cv. Allahabad Safeda. During the study, the highest (10.51’B and 10.63’B) amount of total soluble solids (T.S.S.) were seen under treatment MDLgF, i.e. (mulch +80% DI +100% RDF), while the lowest amounts (8.90’B and 8.97’B) were observed under control in which plants received irrigation through conventional system and 100% recommended dose of fertilizers during 2017 and 2018, respectively (Table 3). Maximum T.S.S. was observed under mulched treatments i.e. 9.81’B and 10.02’B, respectively as compared to un-mulched. Further, the application of drip irrigation at 100 per cent level significantly augmented the T.S.S. (9.72’B and 9.86’B) in the respective years. T.S.S. also changed significantly with the advancement in fertigation levels, wherein maximum T.S.S. (9.78’B and 9.96’B) was observed under 100 per cent recommended dose of fertilizers. The interactive effects of drip irrigation × fertigation and mulch × fertigation were also found statistically non-significant in both the years. This could be as a result of availability of optimum soil temperature, moisture and nutrient supply under mulch in association with drip irrigation, while under control due to absence of mulch, soil temperature fluctuations and moisture evaporation losses were quite common resulting into poor uptake and assimilation and subsequently low T.S.S. content. Further, fertigation at higher potassium doses also improved the total soluble solids which might be due to its effect on photosynthesis and translocation of photosynthates to developing fruits. In accordance with these findings, higher T.S.S. under mulched conditions over non-mulched conditions was also reported by Khan et al. (2013) [6] in guava. Singh et al. (2015) [7] also confirmed that application of polyethylene mulch resulted in higher T.S.S. in guava cv. Allahabad Safeda but in combination with drip irrigation at 80 per cent pan evaporation. Rao et al. (2017) [11] revealed that interaction effect of drip irrigation and fertigation was found to be non-significant in guava cv. L 49. The highest titratable acidity (0.50 per cent and 0.56 per cent) was found under control while lowest (0.38 per cent and 0.35 per cent) under MDLgF, during the years 2017 and 2018 respectively (Table 4). The results revealed that the sole effect of silver polyethylene mulch was significant on titratable acidity during both the years of study. Drip irrigation at 60 per cent level produced significantly higher titratable acidity (0.46 per cent and 0.50 per cent) while the lowest (0.43 per cent and 0.46 per cent) was observed under irrigation at 80 per cent level during the years 2017 and 2018, respectively. Overall effect of fertigation was found to be non-significant throughout the study. Fertigation on the other hand, exhibited no significant effect on titratable acidity. The combined effect of all the main factors i.e. mulch, drip irrigation and fertigation gave non-significant results during both the years. This could be attributed to the favourable moisture and nutrient supply throughout the entire fruit development stage due to the combined influence of all the three factors which promoted the enzymatic activity and further favoured the hydrolysis of metabolites (such as organic acids) resulting into reduced acidity level, under drip irrigation and fertigation in association with mulch. The prevalence of high acidity under no mulch and low acidity under mulched conditions was also reported by Khan et al. (2013) [6] in guava cv. Allahabad Safeda. In line with these results, decline in titratable acidity was also found in guava cv. Shweta when irrigated at 100 per cent level under drip irrigation (Ramnivas et al., 2013) [6]. Bhanukar et al. (2015) [3] also reported similar findings with comparatively low titratable acidity in Kinnow under mulch condition as compared to control i.e. without mulch. Kumar et al. (2015) [7] also reported decline in titratable acidity under black polyethylene mulch in Eureka lemon.

![Image](http://www.chemijournal.com)

Table 1: Effect of drip based NPK fertigation and plastic mulch on per cent increase in plant height of guava cv. VNR Bibi

| Mulch | Irrigation levels | 2017 | 2018 |
|-------|------------------|------|------|
|       | Fertilizer levels | Mean (M × DI) | Mean (M × DI) |
|       | F1 | F2 | F3 | F1 | F2 | F3 |
| M     | DI | 34.80 | 39.03 | 34.15 | 35.99 | 38.75 | 36.40 | 33.79 | 36.31 |
|       | DI | 39.39 | 35.84 | 38.12 | 35.54 | 32.34 | 30.07 | 32.65 |
|       | Mean (M × F) | 37.96 | 34.39 | 33.32 | 35.22 | 32.85 | 30.60 | 32.65 |
| M0    | DI | 37.24 | 35.94 | 33.61 | 34.44 | 34.65 | 34.98 | 30.45 | 31.33 |
|       | DI | 35.94 | 32.07 | 28.29 | 32.10 | 34.11 | 29.85 | 26.49 | 30.15 |
|       | Mean (M × F) | 35.92 | 32.46 | 28.10 | 32.16 | 33.96 | 30.45 | 27.14 | 30.52 |
| I × F | DI | 36.02 | 36.12 | 31.46 | 34.60 | 34.55 | 33.93 | 30.56 | 33.02 |
|       | DI | 37.67 | 35.60 | 32.07 | 35.11 | 36.43 | 33.13 | 30.14 | 33.23 |
|       | Mean (M × F) | 36.27 | 33.05 | 30.28 | 33.20 | 34.01 | 30.90 | 28.05 | 30.99 |
| Mean  | F   | 36.65 | 34.99 | 31.27 | 35.00 | 32.65 | 29.59 | 30.52 | 30.99 |

| Control | Mean | C.D. at 5% | Mean | C.D. at 5% |
|---------|------|------------|------|------------|
| Factor  | 21.58 | 7.32 | 23.75 | 6.97 |
| M       | 2.46 | NS | 3.01 | 2.35 |
| DI      | 1.01 | NS | 1.06 | 1.06 |
| M × DI  | 0.82 | NS | 1.01 | 1.43 |
| F       | 1.43 | NS | 1.75 | 2.48 |

| Factor  | M × F | DI × F | M × DI × F | M × DI × F | M × DI × F |
|---------|-------|--------|------------|------------|------------|
| C.D. at 5% | NS | NS | NS | NS | NS |
| SE(m)   | 1.50 | 1.83 | 2.60 | 1.43 | 1.75 |
Table 2: Effect of drip based NPK fertigation and plastic mulch on per cent increase in plant girth of guava cv. VNR Bihi

| Mulch | Irrigation levels | 2017 | 2018 |
|-------|------------------|------|------|
|       | Fertilizer levels | Mean (M × DI) | Fertilizer levels | Mean (M × DI) |
|       | F1 | F2 | F3 | DI1 | 38.43 | 43.90 | 36.09 | 39.47 | 29.84 | 31.22 | 27.73 | 29.60 |
|       | F2 | F3 | DI2 | 46.82 | 50.29 | 38.45 | 45.19 | 32.64 | 31.83 | 30.22 | 31.56 |
|       | F1 | F2 | DI3 | 41.31 | 36.94 | 32.12 | 36.79 | 31.22 | 28.74 | 27.26 | 29.07 |
|       | F3 | F1 | Mean (M × F) | 42.19 | 43.71 | 35.55 | 40.48 | 31.23 | 30.60 | 28.40 | 30.08 |
| M0    | DI1 | 38.77 | 34.41 | 25.61 | 32.93 | 30.96 | 27.54 | 26.18 | 28.22 |
|       | DI2 | 38.61 | 32.09 | 22.12 | 30.94 | 30.50 | 26.77 | 25.96 | 27.74 |
|       | DI3 | 38.29 | 27.25 | 23.28 | 29.61 | 28.76 | 26.67 | 25.08 | 28.81 |
|       | Mean (M0 × F) | 38.56 | 31.25 | 23.67 | 31.16 | 30.07 | 26.99 | 25.71 | 27.59 |
|   I × F | DI1 | 38.60 | 39.16 | 30.85 | 36.20 | 30.40 | 29.38 | 26.95 | 28.91 |
|       | DI2 | 42.71 | 41.19 | 30.28 | 38.06 | 31.57 | 29.30 | 28.09 | 29.65 |
|       | DI3 | 39.80 | 32.10 | 27.70 | 33.20 | 29.99 | 27.70 | 26.13 | 27.94 |
| Mean  | 40.37 | 37.48 | 29.61 | 30.65 | 28.80 | 27.05 |

Table 3: Effect of drip based NPK fertigation and plastic mulch on T.S.S. of guava cv. VNR Bihi

| Mulch | Irrigation levels | 2017 | 2018 |
|-------|------------------|------|------|
|       | Fertilizer levels | Mean (M × DI) | Fertilizer levels | Mean (M × DI) |
|       | F1 | F2 | F3 | DI1 | 9.52 | 10.28 | 9.32 | 9.70 | 9.98 | 10.26 | 9.78 | 10.00 |
|       | F2 | F3 | DI2 | 10.51 | 10.30 | 9.72 | 10.18 | 10.63 | 10.44 | 9.92 | 10.33 |
|       | F1 | F2 | DI3 | 9.92 | 9.42 | 9.30 | 9.54 | 10.12 | 9.62 | 9.46 | 9.73 |
|       | F3 | F1 | Mean (M × F) | 9.98 | 10.00 | 9.44 | 9.81 | 10.24 | 10.10 | 9.72 | 10.02 |
| M0    | DI1 | 9.72 | 9.52 | 9.22 | 9.48 | 9.88 | 9.68 | 9.30 | 9.62 |
|       | DI2 | 9.62 | 9.25 | 8.94 | 9.27 | 9.70 | 9.33 | 9.18 | 9.40 |
|       | DI3 | 9.42 | 9.12 | 9.03 | 9.19 | 9.45 | 9.22 | 9.12 | 9.26 |
|       | Mean (M0 × F) | 9.58 | 9.29 | 9.06 | 9.31 | 9.67 | 9.41 | 9.20 | 9.43 |
|   I × F | DI1 | 9.62 | 9.90 | 9.27 | 9.59 | 9.92 | 9.97 | 9.54 | 9.81 |
|       | DI2 | 10.06 | 9.78 | 9.33 | 9.72 | 10.16 | 9.88 | 9.55 | 9.86 |
|       | DI3 | 9.67 | 9.27 | 9.16 | 9.36 | 9.78 | 9.42 | 9.29 | 9.49 |
| Mean  | 9.78 | 9.65 | 9.25 | 9.76 | 9.96 | 9.76 | 9.46 |

Table 4: Effect of drip based NPK fertigation and plastic mulch on acidity of guava cv. VNR Bihi

| Mulch | Irrigation levels | 2017 | 2018 |
|-------|------------------|------|------|
|       | Fertilizer levels | Mean (M × DI) | Fertilizer levels | Mean (M × DI) |
|       | F1 | F2 | F3 | DI1 | 0.46 | 0.43 | 0.46 | 0.45 | 0.43 | 0.40 | 0.43 | 0.42 |
|       | F2 | F3 | DI2 | 0.38 | 0.41 | 0.44 | 0.41 | 0.35 | 0.38 | 0.47 | 0.40 |
|       | F1 | F2 | DI3 | 0.43 | 0.46 | 0.48 | 0.45 | 0.45 | 0.39 | 0.48 | 0.45 |
|       | F3 | F1 | Mean (M × F) | 0.42 | 0.43 | 0.45 | 0.43 | 0.41 | 0.42 | 0.46 | 0.43 |
| M0    | DI1 | 0.43 | 0.45 | 0.46 | 0.45 | 0.46 | 0.48 | 0.50 | 0.48 |
|       | DI2 | 0.46 | 0.45 | 0.46 | 0.46 | 0.50 | 0.49 | 0.51 | 0.49 |
|       | DI3 | 0.47 | 0.47 | 0.48 | 0.48 | 0.51 | 0.52 | 0.53 | 0.51 |
|       | Mean (M0 × F) | 0.45 | 0.46 | 0.47 | 0.46 | 0.49 | 0.50 | 0.51 | 0.50 |
|   I × F | DI1 | 0.44 | 0.45 | 0.47 | 0.45 | 0.44 | 0.43 | 0.47 | 0.45 |
|       | DI2 | 0.42 | 0.43 | 0.45 | 0.43 | 0.42 | 0.44 | 0.48 | 0.46 |
Conclusion
It can be consoled that mulch along with 80% DI and 100% RDF can improve vegetative growth and chemical attributes of guava in Tarai region.

References
1. AOAC. Official Methods of Analysis, Association of Official Analytical Chemist, 15th Edn. Washington, DC, USA, 1990.
2. Bhanukar M, Sindhu, Preeti SS, Prince. Effect of various mulches on growth, yield and quality of Kinnow. The Bioscan. 2015; 525:201-07.
3. Bar Yosef B. Advances in fertigation. Advances in Agronomy. 1999; 65:1-75.
4. Catin B, Yazgan S, Tipti T. Economics of drip irrigation of olives in Turkey. Agriculture Water Management. 2004; 66:145-51.
5. Garg N, Singh G, Yadav P, Goyal N, Soni MK. Effect of mulching on microbial population in guava orchard soils. Indian Journal Agriculture Sciences. 2007; 77:241-43.
6. Khan JN, Jain AK, Sharma R, Singh NP, Gill PP, Kaur S. Growth, yield and nutrient uptake of guava (Psidium guajava L.) affected by soil matric potential, fertigation and mulching under drip irrigation. Agricultural Engineering International: CIGR Journal. 2013; 15(3):17-28.
7. Kumar V, Bhat AK, Sharma V, Gupta N, Sohan P, Singh VB. Effect of different mulches on soil moisture, growth and yield of Eureka lemon (Citrus limon burm) under rainfed condition. Indian Journal of Dryland Agricultural Research and Development. 2015; 30(1):83-88.
8. Rammiwas, Kaushik RA, Sarolia DK, Pareek S, Singh V. Effect of irrigation and fertigation scheduling on growth and yield of guava (Psidium guajava L.) under meadow orcharding. African Journal of agriculture Research. 2012; 7(47):6350-6356.
9. Rangana S. Handbook of Analysis and quality control for fruit and vegetable products, Tata MC Grow-Hill Ltd., New Delhi, India.
10. Raskar BS. Effect of planting technique and fertigation on growth, yield and quality of banana (Musa sp). Indian Journal of Agronomy. 2003; 48(3):235-237.
11. Rao KR, Gangwar S, Bajpai A, Chourasiya L, Soni K. Influence of growth, yield and quality of guava (Psidium guajava L.) by drip irrigation and fertigation. Journal of Applied and Natural Science. 2017; 9(1):642-645.
12. Shirigure PS, Srivastava AK, Singh S. Effect of pan evaporation based irrigation scheduling on yield and quality of drip irrigated Nagpur mandarin (Citrus reticulata). Indian Journal of Agricultural Sciences. 2001b; 71(4):264-266.
13. Singh P, Singh AK, Sahu K. Irrigation and fertigation of pomegranate cv. Ganesh in Chhattisgarh. Indian Journal of Horticulture. 2006; 63:148-51.
14. Singh HP, Singh G. Nutrient and water management in guava. Acta Horticulturae. (ISHS). 2007; 735:389-397.
15. Singh VK, Singh G, Bhriguvasani SR. Effect of polyethylene mulch on soil nutrient level and root, leaf and fruiting characteristics of mango (Mangifera indica). Indian Journal of Agriculture Sciences. 2009; 79:411-17.
16. Singh VK, Soni MK, Singh A. Effect of drip irrigation and polyethylene mulching on fruit yield and quality of guava cv. Allahabad Safeda under meadow orcharding. Indian Journal of Horticulture. 2015; 72(4):479-84.
17. Sulochanamma BN, Reddy TY, Reddy GS. Effect of basin and drip irrigation on growth, yield and water use efficiency in pomegranate cv. Ganesh. Acta Horticulturae. 2005; 696:277-279.
18. Viers FG, JR. Water deficits and plant growth, Vol.-III (ed. T. T. Kozlowski). Academic Press Incharge, New York and London, 1972.
19. Vorosmarty CJ, Green P, Salisbury J, Lammers RB. Global Water Resources: Vulnerability from Climate Change and Population Growth Science. 2000; 289(5477):284-88.
20. Wei, Hao. ‘Freezing tolerance and cold acclimation in guava (Psidium guajava L.)’. MSc thesis, IOWA State University, Ames, IOWA, 2008, 61.