



Research Article

Thermal Requirement and Fruit Tree Response of Ber (*Zizyphus mauritiana* Lamk.) Cultivars in a Semi-arid Region of Punjab

NAVJOT GUPTA¹, K.K. GILL^{2*} AND RITU BABUTA²

¹Punjab Agricultural University, Regional Research Station, Bathinda-151001, Punjab

²School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana-141004, Punjab

ABSTRACT

The phenological and fruit quality parameters of nine ber cultivars were studied for their heat unit requirements at the Regional Station, Bathinda, Punjab during 2007-2009. Among the varieties under study, *Seb* took minimum and *Katha Phal* maximum heat units during their growth period. The earliest initiation of fruit setting occurred in *Seb* while *Gola* and *Katha Phal* have taken the maximum days for fruit set initiation. Varieties *Seb* and *Chuhara* required minimum period for fruit setting, while *Katha Phal* took the maximum period. The range of heat units was between 3868 and 4529 °C day for fruit ripening in all the varieties. *Muria Murhera* and *Umran* were superior to other varieties with regard to fruit yield. The minimum fruit weight was recorded in *Chuhara*. Total soluble solid content ranged from 14 to 19% among the varieties, and acidity varied as 0.28-0.71% with a maximum in *Katha Phal* and a minimum in *Chuhara*. The pulp percentage and pulp stone ratio were higher in *Umran* followed by *Seb*. Overall, *Umran* outshined all the other cultivars with maximum yield, fruit weight, pulp percentage and pulp stone ratio.

Key words: Heat units, Yield, Quality, Meteorological parameters, Ber

Introduction

Ber (*Zizyphus mauritiana* Lamk.) is an ancient and indigenous fruit of India, China and Malaysia regions. The ripe fruit is rich in protein, phosphorus, calcium, carotene and vitamin C, and nutritionally richer than the apple. The ber is a hardy fruit and it favours hot and dry climate. The crop withstands high temperature and aridity by cessation of growth, leaf fall and dormancy phase. The effect of temperature on fruit plant is accounted through the heat unit which is conceptually the temperature requirement for completion of stages of ontogenesis. Temperature is preliminary the major determinant of growth,

development and yield of fruit crops in arid and semi-arid environments. Seeding to maturity is related to accumulation of heat or temperature units above a threshold or base temperature, below which growth is impeded. Several phenological models have been prepared to predict the duration of a certain phenophase by using growing degree-days (GDD), photothermal units (PTU) and other thermal units (Khichar and Niwas, 2007; Pandey *et al.*, 2010). The accumulated GDD or PTUs for each phenophase varies with variety. The present investigation was, therefore, carried out to assess the duration of developmental phases of some varieties of ber in a semi-arid region, and their association with yield determinants.

*Corresponding author,
Email: kgill2002@gmail.com

Materials and Methods

The study area (Bathinda, 30°17' N, 74°58'E, 211 m amsl) is semi-arid and falls in agro-climatic zone-V of Punjab. June is the warmest month of the year, with mean daily maximum and minimum temperature of 41°C and 26°C, respectively. January is the coldest month with mean daily maximum and minimum temperature of 20°C and 4°C, respectively. Mean annual rainfall is 424 mm, 80% of which is received through south-west monsoon (1st week of July to mid of September). Strong winds coupled with dust storms prevail during the months of May and June, while frosty nights and chilled winds are most common during December and January months. The soil is sandy loam and characterized with pH (8.31), organic carbon (0.32%), electrical conductivity (0.24 dS m⁻¹), available N (212 kg ha⁻¹), available P (21.5 kg ha⁻¹) and available K (357.0 kg ha⁻¹).

The phenological and fruit quality parameters of nine ber cultivars were studied viz., *Gola*, *Muria Murhera*, *Sandhura Narnaul*, *Katha Phal*, *Umran*, *Seb*, *Najuk*, *Chuhara* and *Walaiti* for their heat unit requirements during 2007-08 and 2008-09. The parameters were fruit yield (kg ha⁻¹), fruit weight (g), stone weight (g), total soluble

solids (TSS), acidity (%) and pulp percentage. The heat units as growing degree days (GDD) during phenological stages were calculated using 10°C as the base temperature (Mishra and Krska, 2009). The treatment was replicated thrice in a randomized block design. Weather data was collected from the agrometeorological observatory. Growing degree days (GDD) were calculated from the date of pruning to the ripening of the varieties (May-March) following Nuttonson (1955).

Heat use efficiency was worked out as.

$$\text{HUE} = \text{Yield} / \text{Accumulated GDD (kg } ^\circ\text{C-day}^{-1}\text{)}$$

Different phenological stages like initiation of flowering, flower in full bloom, initiation of fruit set, final fruit set and fruit ripening were recorded by observing plants on every alternate day.

Results and Discussion

The weather conditions during the study periods are given in Fig. 1 & 2. The minimum temperature was near-to-normal during 2007-08 except in November 2007 (above normal) and January-February, 2008 (below normal). The maximum temperature was also similar to normal

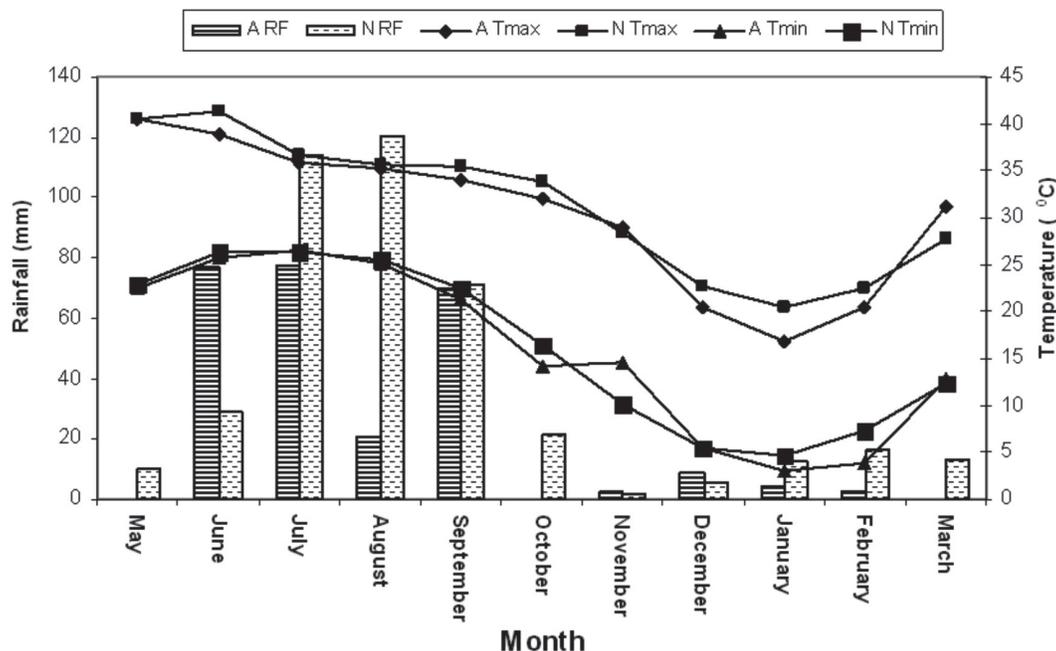


Fig. 1. Actual and normal rainfall, Tmax. & Tmin. during 2007-08 at Bathinda

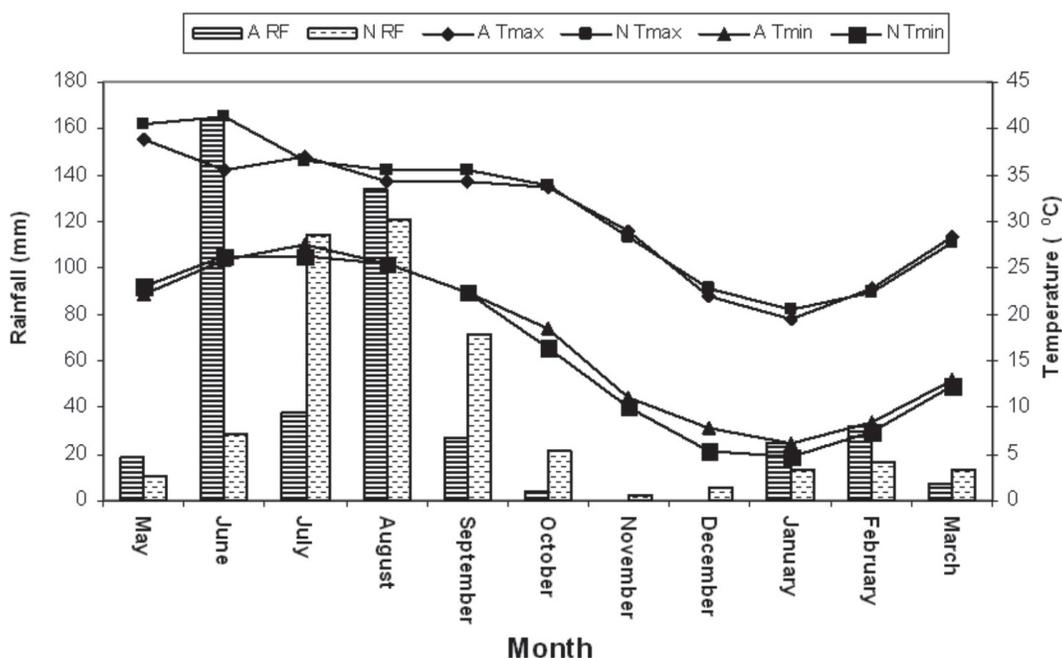


Fig. 2. Actual and normal rainfall, Tmax. & Tmin. during 2008-09 at Bathinda

temperature, or slightly below during 2007-08 (May-March). During 2008-09, minimum temperatures were nearly normal during May-September and slightly above normal in October-March. The maximum temperature was near or slightly below normal during 2007-08. A total of 263.5 and 450.9 mm of rainfall was received during May-March 2007-08 and 2008-09, respectively against the normal of 417.1 mm.

Phenology of varieties

Number of days to attain a particular phenolohase differed among the varieties and between the years (Table 1 & 2). During 2007-08, varieties (except *Seb*) took larger number of days to complete different phenological stages compared to 2008-09. Varieties took 82-132 and 108-127 days for initiation and 97-148 and 125-144 days for full bloom of flowers during 2007-08 and 2008-09, respectively. The variety *Seb* required minimum and *Katha Phal* the maximum number of days during 2007-08. During 2008-09, *Chuhara* and *Walaiti* took minimum and maximum number of days, respectively for full bloom. Fruit set initiation was completed in 133-155 days and 140-149 days in 2007-08 and 2008-09, respectively. Minimum period was taken by

Seb (both the years), *Umran* and *Muria Murhera* (in 2008-09), and the maximum pertained to *Waillaiti* (2007-08) and *Gola* (2008-09). The fruit setting was completed in 158-172 days and 162-169 days in respective years with the earliest completion in *Seb* (2007-08) and *Chuhara* (2008-09), and the late completion by *Sandhura Narnaul* (2007-08) and *Seb* and *Najukin* (2008-09). Overall, varieties completed the ripening stage in 279-341 and 276-338 days during 2007-08 and 2008-09, respectively. The minimum number of days was taken by *Gola* while *Seb* took the maximum in both the years. It may be that the early maturing varieties usually took smaller period from bud burst to fruit set, thus resulting in early ripening.

Heat unit requirement

The varieties have taken 1779-2756 and 2089-3012 °C-day heat units to reach to its flowering initiation and full bloom stage during 2007-08. The heat units were 2505-2625 and 2642-2908 °C-day for attaining these stages during 2008-09. For both the stages, maximum and minimum heat units were consumed by *Seb* and *Katha Phal* in 2007-08. However, during 2008-09, minimum and maximum GDDs

Table 1. Heat unit requirement for different cultivars of Ber during 2007-08

Varieties	Heat units requirement (°C day)					Yield (kg/tree)	HUE (Kg/°C day)
	Flowering initiation	Flowering full bloom	Fruit set initiation	Fruit set	Fruit ripening		
Gola	1976	2889	3027	3252	3769	67.8	3.24
	92	140	149	167	279		
Muria murhera	2630	2889	2919	3226	4035	72.5	3.23
	125	140	142	165	312		
Sandhura Narnaul	2559	2934	3055	3318	3978	62.0	2.81
	121	143	151	172	307		
Katha Phal	2756	3012	3055	3292	4180	64.5	2.78
	132	148	151	170	323		
Umran	2630	2905	2919	3201	4252	68.5	2.90
	125	141	142	163	328		
Seb	1779	2089	2765	3149	4431	62.0	2.52
	82	97	133	158	341		
Najuk	2690	2905	2934	3227	4125	60.3	2.63
	128	141	143	165	319		
Chhurara	2630	2872	2919	3227	4125	62.5	2.73
	125	139	142	165	319		
Waillati	2717	2950	3110	3292	4125	37.5	1.64
	130	144	155	170	319		
CD 5%	-	-	-	-	-	7.8	0.41

Table 2. Heat unit requirement for different cultivars of Ber during 2008-09

Varieties	Heat units requirement (°C day)					Yield (kg/tree)	HUE (Kg/°C day)
	Flowering initiation	Flowering full bloom	Fruit set initiation	Fruit set	Fruit ripening		
Gola	2605	2888	3026	3257	3966	26.3	1.19
	126	142	149	164	276		
Muria Murhera	2584	2685	2848	3243	4306	43.8	1.83
	125	131	140	163	314		
Sandhura Narnaul	2543	2751	2949	3272	4242	41.3	1.75
	123	135	145	165	309		
Katha Phal	2625	2908	2970	3313	4393	27.5	1.13
	127	143	146	168	322		
Umran	2564	2848	2848	3299	4405	50.5	2.06
	124	140	140	167	323		
Seb	2558	2751	2848	3227	4626	26.3	1.02
	108	125	140	169	338		
Najuk	2604	2827	2868	3227	4319	46.3	1.93
	126	139	141	169	315		
Chhurara	2505	2642	2868	3228	4296	61.3	2.57
	121	128	141	162	313		
Waillati	2605	2929	2888	3299	4242	29.5	1.25
	126	144	142	167	309		
CD 5%	-	-	-	-	-	5.6	0.30

corresponded to *Chhuhara* and *Katha Phal* (and *Walaiti*), respectively. For fruit initiation, *Seb* required 2765 °C-day (minimum) and *Walaiti* 3110 °C-day (maximum) GDDs in 2007-08. During 2008-09, *Seb*, *Umran* and *Muria Murhera* consumed 2848 °C-day, while *Gola* consumed 3026 °C-day for fruit set initiation, which were the minimum and the maximum values among the varieties. The varieties under study consumed heat units of 3149 to 3318 (°C day) for fruit setting during 2007-08. *Seb* consumed minimum while *Sandhura Narnaul* consumed maximum heat units. The heat unit consumption for fruit setting was ranged from 3227 to 3313 (°C day) during 2008-09. The varieties *Seb* and *Najuk* consumed minimum while the *Katha Phal* consumed maximum. Singh and Bhatia (2012) also reported that the heat unit consumption varied among the different varieties of apple. The heat unit consumption for fruit ripening ranged from 3769 to 4431 (°C day) during 2007-08 and from 3966 to 4626 (°C day) during 2008-09. Minimum heat units were consumed by *Gola* while the maximum heat units were consumed by *Seb* in both the years under study. Singh *et al.* (1999) also reported that the *Gola* fruits matured earlier because they needed less thermal time (heat units) than others, from fruit setting to first harvest of fruits.

Fruit yield and quality

The fruit yield of all the varieties under study was higher during 2007-08 as compared to 2008-09 (Table 3 & 4). During 2007-08, the fruit yield

was significantly higher in *Muria Murhera* (72.5 kg /tree) which was at par with the fruit yield of *Umran* and *Gola*. The fruit yield was recorded significantly lower in *Walaiti*. Fruit yield was recorded significantly higher (61.3 kg /tree) in *Chhuhara* followed by *Umran* and minimum (26.3 kg /tree) in *Gola* during 2008-09. Fruit weight was recorded significantly higher (30.5 and 28.9g) in *Umran* during 2007-08 and 2008-09, respectively (Table 3 & 4), while the minimum weight was recorded in *Najuk* (10.3g) during 2007-08 and in *Chhuhara* (13.3g) during 2008-09. Stone weight was minimum in *Najuk* followed by *Gola* during 2007-08 and in *Chhuhara* followed by *Gola* during 2008-09. The TSS was ranged from 13.3 to 18.8% and from 13.8 to 19.7% among various varieties during 2007-08 and 2008-09 respectively. The TSS was recorded maximum in *Najuk* during both the years. The acidity ranged from 0.30 to 0.99 and 0.26 to 0.77%, respectively during 2007-08 and 2008-09. The acidity was found minimum in *Chhuhara* during both the years. The pulp percentage was found significantly more in *Umran* (96.3 and 95.7%) during 2007-08 and 2008-09, respectively.

Heat Use Efficiency (HUE)

The growing degree days (GDD) or thermal time concept assumes that the amount of heat would nearly be the same for a crop to reach a particular phenological stage or maturity. The accumulated GDD to reach fruit set stage and physiological maturity varied in all the varieties.

Table 3. Yield characteristics and quality of ber varieties during 2007-08

Varieties	Fruit Weight (g)	Stone weight (g)	TSS (%)	Acidity (%)	Pulp (%)
Gola	15.7	0.9	17.7	0.67	94.2
Muria Murhera	24.0	1.3	13.3	0.99	94.7
Sandura Narnaul	18.5	1.2	14.6	0.88	93.4
Katha Phal	13.6	1.0	17.2	0.66	92.7
Umran	30.5	1.1	16.1	0.40	96.3
Seb	22.3	1.3	16.3	0.36	94.1
Najuk	10.3	0.8	18.8	0.34	92.2
Chhuhara	11.6	1.0	18.6	0.30	91.8
Walaiti	16.2	1.2	13.9	0.43	92.9
CD (5%)	1.43	0.14	0.41	0.11	0.99

Table 4. Yield characteristics and quality of ber varieties during 2008-09

Varieties	Fruit Weight (g)	Stone weight (g)	TSS (%)	Acidity (%)	Pulp (%)
<i>Gola</i>	13.5	0.9	12.4	0.38	93.3
<i>Muria Murhera</i>	22.5	1.3	14.1	0.28	94.3
<i>Sandura Narnaul</i>	20.5	1.4	13.8	0.36	93.4
<i>Katha Phal</i>	17.0	1.2	14.1	0.77	92.8
<i>Umran</i>	28.9	1.3	19.4	0.39	95.7
<i>Seb</i>	25.5	1.3	17.6	0.43	95.1
<i>Najuk</i>	15.9	1.1	19.4	0.37	93.1
<i>Chhuhara</i>	13.3	0.8	19.7	0.26	94.2
<i>Walaiti</i>	19.4	1.2	16.0	0.52	93.7
CD (5%)	1.27	0.12	0.38	0.03	0.71

On an average the growth rate of the variety *Gola* and *Muria Murhera* was significantly higher as compared to the others, as indicated by the highest heat use efficiency of 3.24 and 3.23 kg/ °C day respectively, during 2007-08. The highest heat use efficiency of *Gola* fruits was also reported by Singh *et al.*, 1999. However, during 2008-09 significantly higher (2.57 kg/ °C day) heat use efficiency of was observed in *Chhuhara* followed by *Umran* (2.06 kg/ °C day). The lowest heat use efficiency was observed in *Walaiti* during 2007-08 and in *Seb* during 2008-09. This may be due to the reason that the fruit yield was less in *Walaiti* and *Seb* cultivars as compared to the other varieties. The value of heat use efficiency was slightly higher during the 2007-08 in most of the varieties as compared to 2008-09 which indicates that the thermal environment was more favorable in the first season, and the crop acquires a wide range of temperatures during first season as compared to the second.

Conclusions

All the varieties under study took more number of days to complete different phenological stages i.e., flowering initiation, full bloom, fruit set initiation, fruit set and fruit ripening during 2007-08 as compared to 2008-09 except the variety *Seb*. *Gola* consumed minimum while *Seb* consumed maximum heat units for fruit ripening. Early ripening varieties consumed lesser heat units whereas the late varieties consumed more heat units. The varieties *Muria Murhera* and *Umran* were superior to other varieties with

regard to fruit yield. On an average the growth rate of the variety *Gola* and *Muria Murhera* was highest as compared to the others as indicated by the highest heat use efficiency.

References

- Khichar, M.L. and Niwas, R. 2007. Thermal effect on growth and yield of wheat under different sowing environments and planting systems. *Indian J. Agric. Res.*, **41**: 92-96.
- Mishra, S. and Krska, B. 2009. Temperature as the basic factor influencing phenological stages in *Ziziphus jujuba* Mill. *Acta Univ. Agric. et Silv. Mendel. Brun.*, LVII, No. 1, pp. 89-96
- Nuttonson, M.Y. 1955. Wheat climate relationships and use of phenology in ascertaining the thermal and photothermal requirements of wheat. *American Institute of Crop Ecology*, Washington DC, pp 388.
- Pandey, I.B., Pandey, R.K., Dwivedi, D.K. and Singh, R.S. 2010. Phenology, heat unit requirement and yield of wheat (*Triticum aestivum* L.) varieties under different crop growing environments. *Indian J. Agric. Sci.*, **80** : 136-140.
- Singh, M. and Bhatia, H.S. 2012. Thermal indices in relation to crop phenology and fruit yield of apple. *Mausam*, **63**: 449-454.
- Singh, R.S., Prasad, R.N., Gupta, J.P., Vashistha, B.B and Ramakrishna, Y.S. 1999. Thermal time requirement for fruit development and maturity of jujube (*Ziziphus mauritiana*) grown under rainfed conditions in Indian hot desert. *Annals of Arid Zone* . **38**: 161-166.