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Response of jujube cultivars to natural climatic variability under rain fed condition in arid zone

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ABSTRACT

Arid zones all over the world are climatically constrained and ecosystems fragile ecosystem that support specialized and adapted plants species. Jujube (*Ziziphus mauritiana* Lam.) or *ber* is one of such species which supports the livelihood of desert farmers. The jujube trees can tolerate high temperature (49-50°C) during dormancy, but flowering and fruiting are affected at temperature >35° C. During recent decade, there has been slight rise in temperature and decrease in relative humidity in September to November in Indian arid zone which led to reduction fruit yield. This study was made on an established orchard of 22 cultivars of jujube at 6x6m spacing in RBD replicated thrice. The orchard was maintained under uniform cultural practices and rain fed condition from 1991 to 2013 under natural climatic variability in respect of rainfall, temperature and relative humidity. These climatic parameters recorded for two decades i.e. 1991-2000 and 2001-2010 were related with fruit yield and regression equation developed. The fruit yield was found to be positively correlated with annual rain fall irrespective of varieties. The varieties Gola, CAZRI-Gola, Mundia, Maharvali, Illaichi and Tikadi maintained higher fruit yield under drought and low rainfall years. The developed regression equation could be used to predict fruit yield of a variety based upon rainfall. This was also validated by chi-square test.

Keywords: Jujube, *ber,* climatic variability, rain fall, temperature, fruit yield, regression analysis.

INTRODUCTION

Ber (*Ziziphus mauritiana* Lam.) is an important sub-tropical fruit, which is cultivated all over the drier parts of Indian sub-continent for its fresh fruits. The fruits are rich nutrients especially vitamin C, A, B-complex and minerals. Growing of *ber* provides a sure substantial part of livelihood to desert farmers who often face the crop failures due to low and erratic rainfall and frequent drought. The impact of projected climate change by the end of 21st Century (IPCC, 2007) is more likely in arid region than in the semi-arid or sub-humid regions of India. IPCC predictions for arid zone of India indicate a rise in temperature by 4°-5°C across the region by the end of this century. Rainfall is expected to decline up to 30% in northern part and increase up to 15% in southern and eastern parts of western Rajasthan (Rupakumar *et al*., 2006). Such situations will affect soil moisture balance, plant physiology, quality and yield of crops. *Ber* trees can withstand extreme high temperature during dormancy period, however fruit set is affected at temperature above 35° C (Pareek, 2001). Climate projection studies indicate a general increase of temperature from 3-6°C with more warming in the northern parts than the southern parts of India (Lonergan, 1998, The Energy Resources Institute 2001). Another study predicts 1-4°C rise in temperature by the year 2030 (Sharma and Chauhan, 2011) and 2-4.8°C increase by 2080 through ensemble modelling based on Fifth Report of IPCC (Chaturvedi *et al*., 2012). In north western parts of India, leaf senescence and leaf fall begins in May and new leaves emerge with the onset of monsoon during June-July. Of late *ber* orchards in Rajasthan have been showing decreased fruit set and inconsistent yield and some time fruit cracking due to climatic variability and unexpected rainfall at fruit maturity. In normal course pruning during the month of May, flowering in *ber* starts in the middle of August and most of the fruit set occurs during middle of September to end of October. However, under the influence of climate change, past 20 year's data with respect to temperature and relative humidity during September to November is showing the upward trends in maximum temperature and decrease in relative humidity. The response of 22 cultivars of *ber* has been studied under this natural climatic variability at Jodhpur over the period of more than 20 years (1991-2010) to delineate the cultivars more resilient to climatic variability.

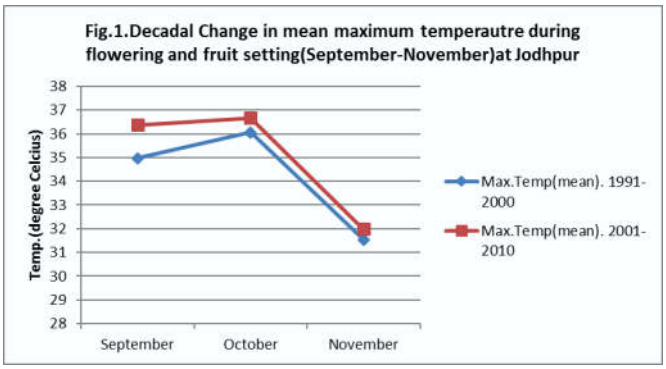
MATERIALS AND METHODS

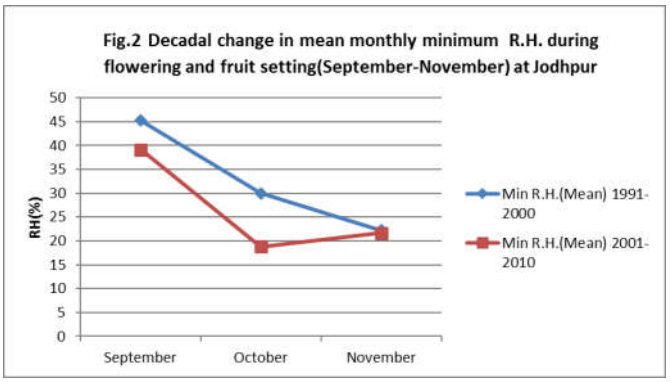
Mean data of maximum temperature and minimum relative humidity during the month of September, October and November for two decades i.e. 1991-2000 and 2001-2010 obtained from the division of Natural Resources and Environment, Central Arid Zone Research Institute, Jodhpur were analyzed. The fruit orchard of 22 cultivars of *ber* planted in 1978 in Randomized Block Design with three replications having 15 plants per replication were studied for fruit retention and yield. The plants were maintained under rainfed condition and uniform cultural practices. The fruit yield were recorded from three plant per replication from each variety from the fruiting season 1991-92 to 2013-14 to calculate the mean fruit yield. The mean fruit yield data from 2001 to 2010 were taken as dependent variable with annual rainfall as independent variable to work out correlation and to develop regression equation. The equation developed on the basis of ten years data were applied to estimate the fruit yield for three consecutive years (2011-2013). Chi-square test were applied to validate the equation. The experiment on pruning time was conducted 2010-11 on 25 years old uniform plantation of *ber* var. Gola maintained under identical cultural practices except for differential pruning dates. The plants were pruned on seven dates (Table 6). The data were recorded on vegetative growth, fruit setting, fruit drop, fruit yield and physico-chemical parameters of fruits during both the years. The fruit cracking in 22 cultivars of *ber* was recorded after heavy rainfall events in February, 2011. Four primary branches were selected in four direction on three plants of each variety and total number of cracked and uncracked fruits were counted. The data were analyzed for per cent cracking, mean weight and specific gravity of cracked fruits.

RESULTS AND DISCUSSION

The fruit yield of 22 *ber* cultivars recorded for two decades i.e. 1991-2000 and 2001-2010 are given in Table 1&2. Since the experiment was on rainfed condition with similar cultural practices, the yield varied due to varieties, rainfall, temperature and relative humidity. The fruit set/fruit drop and final retention and consequent fruit yield were affected most by high temperature (>35^{0}C) and lower relative humidity during September to November and therefore, maximum temperature and minimum relative humidity during this period was analyzed for the last two decade to see its effect on total fruit yield of ber. Mean maximum temperature during the month of September in the decade 1991-2000 was 35^{o}C which increased to 36.37 ^{o}C in the decade 2001-2010 (Fig. 1). Similar changes in maximum temperature from 1991-2000 to 2001-2010 was 36.1^{o}C to 36.67 ^{o}C in October and 31.5 ^{o}C to 31.9 ^{o}C in November were also recorded. Thus, there was a trend of increasing mean monthly maximum temperature during September, October and November from decade 1991-2000 to 2001-2010 (Fig. 1). Fruit set is affected at temperatures above 35^{o}C (Pareek, 2001). Higher fruit yield has been recorded during high rain fall years irrespective of variety as also observed by Singh *et al.* (1998).

Mean minimum relative humidity (RH) during the same months showed decline in the decade 2001-2010 as compared to the same period during the decade 1991-2000 (Fig. 2). Evidently a perceptible change in increased air temperature and decline in relative humidity over 1991-2000 has been observed which might have affected flowering and fruiting behavior leading to decreased fruit yield in different cultivars of *ber*.





Yield in four rainfall situations

Fruit yield of 22 cultivars was recorded every year since its plantation. However, the yield of 22 cultivars during

normal (1995), subnormal (2000), drought year (2002) and in above normal rainfall situation (2010) appeared correlated with the quantum of rain fall (Table 2). Their yield during 1995 (341.9mm) to 2000 (292 mm) and 2002(50 mm) showed a definite declining trend in all cultivars. The maximum decline was in CAZRI Gola i.e., 55% in the 2000 over 1995, 63.77% in 2002 over 2000 and overall decline of 83.72 % in 2002 over 1995. Similar decline were also noted in other varieties. The varieties Gola, Illaichi, Mahawali and Tikadi yielded more than 10 kg fruits per plant even under drought condition with merely 50 mm of rain fall during the year 2002. The fruit yield sharply increased in 2010 with increased rainfall. The comparative increase in fruit yield due to increased rainfall was to a lesser extent in those varieties which gave higher yield under drought condition (Gola, Tikadi and Jogia). The varieties CAZRI Gola, Sanaur-5, Umran and Gola were more responsive to high rainfall by recording more than 60 kg fruits per plant.

Fruit cracking

The incidence of fruit cracking varies greatly among climatic regions and seasons of fruiting in different fruits. The environmental factors associated with fruit cracking include soil moisture, rainfall, temperature, relative humidity and sunlight. Under the changing climatic conditions the fluctuation in these climatic variables are more pronounced in general which may lead to increased fruit cracking in many fruit crops. Rain induced fruit cracking has been reported a serious and costly problem for sweet cherry growers (Simon, 2006). In *ber*, it is often followed by sudden heavy rain at the time of fruit maturity or in the fruit approaching maturity. There was unexpected rain (15.8 mm) during the month of February 2011 which caused severe fruit cracking. It was observed in 12 of 22 cultivars while six cultivars were found completely resistant to cracking. Maximum cracked fruit were in variety Seb (60%) and minimum in Chuhara and Sanaur-5 (Table 4). The analysis of specific gravity of cracked fruits indicated that the severity of cracking was more in slightly immature fruit with specific gravity of less than 0.98, while it was relatively less in mature fruit with a specific gravity of about one (Cvs. Chhuhara, Tikadi, Sanaur-5). The highest per cent cracking was recorded in variety Seb which had specific gravity of 0.93. The cultivars, Illaichi, Banarasi Karaka, Katha, Umran,

Table 1: Mean fruit yield (kg plant^{-1}) of *ber* cultivars during 1991-2000 under different rainfall conditions

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
Rain fall(mm)	204	239.2	326.2	598.9	339.6	628.2	440	478.5	296.1	292.8	384.35
Cultivars											
CAZRI Gola	37.2	35.97	32.59	46.28	33.86	54.5	49.2	50.2	38.25	39.21	41.73
Rashmi	18.12	19.21	22.97	11.67	15.75	27.52	16.58	21.25	18.23	13.13	18.443
Bagwadi	19.2	20.18	13.31	18.2	20.74	24.61	21.25	23.25	20.58	18.15	19.95
Mundia	23.4	25.8	27.32	22.6	26.06	26.59	28.52	31.2	24.12	21.7	25.73
ZG-3	13.22	15.82	29.91	16.76	18.3	21.44	17.22	23.85	19.52	15	19.10
Katha	15.52	17.26	22.87	20.8	27.24	25.32	22.24	23.52	17.2	17.4	20.94
Banarasi Karaka	18.72	19.69	23.31	19.76	19.09	25.03	22.82	23.45	16.23	20.8	20.89
Banarasi Pebandi	16.25	21.16	19.37	16.41	18.14	19.54	23.24	26.23	21.45	17.2	19.90
Aliganj	17.23	20.68	18.29	11.35	14.95	20.11	16.32	21.45	15.6	15.86	17.18
Kaithali	20.2	21.65	23.53	16.23	24.66	21.34	22.2	24.21	21.2	21.79	21.70
Chhuhara	22.82	26.24	24.94	26.7	26.74	28.38	26.22	29.15	22.23	24.26	25.77
Maharwali	17.2	16.15	21.13	12.95	21.96	19.1	21.25	25.62	20.23	19.29	19.49
Thornless	17.23	20.41	19.28	18.82	16	20.77	16.21	20.25	16.52	17.26	18.28
Seb	16.82	18.98	18.86	23.04	17.03	23.38	27.52	31.2	25.3	19.5	22.16
Sanaur-5	20.12	21	22.74	15.39	15.59	19.82	24.82	27.52	19.36	18.1	20.45
Kali	15.25	17.44	17.29	17.78	21.59	23.25	21.35	26.32	23.21	17.2	20.07
Dandan	22.25	23.13	23.77	18.68	18.15	23.9	23.52	22.8	16.28	23.29	21.58
Umran	13.22	18.59	17.89	19.8	18.82	23.93	18.12	21.23	17.52	17.02	18.61
Gola	33.5	36.59	35.39	42.17	29.34	47.46	37.21	36.23	31.25	36.86	36.60
Jogia	18.25	20.32	20.55	17.80	20.74	22.19	11.32	12.25	11.23	19.32	17.40
Illaichi	17.2	20.13	23.32	15.04	15.87	21.35	15.85	19.62	15.45	13.20	17.20
Tikadi	17.32	19.31	20.09	10.81	18.22	21.05	20.82	22.12	16.58	12.8	17.912
Mean	19.56	21.62	22.67	19.96	20.86	25.48	22.90	25.87	20.34	19.92	
CD(P=0.05)	2.33	1.53	1.50	1.26	1.39	1.40	0.77	0.70	0.73	0.46	

Table 2: Mean fruit yield (kg plant^{-1}) of *ber* cultivars during 2001-2010 under different rainfall conditions

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
Rain fall(mm)	437.2	50	419.7	219.8	283	270.4	437.8	212	212	562.2	310.41
Cultivars											
CAZRI Gola	45.2	**5.5**	51.2	**22.2**	27.2	25.2	44.3	**23.9**	**21.8**	64.2	**33.07**
Rashmi	14.2	1.9	19.3	10.5	13.5	12.2	15.8	9.2	11.6	31.2	13.94
Bagwadi	15.1	2.4	16.6	13.5	15.5	14.6	16.8	11.8	10.2	31.5	14.80
Mundia	17	**5.6**	27.5	**21.2**	22.2	21.2	18.5	**18.8**	**24.2**	37.4	**21.36**
ZG-3	12.5	2.5	17.3	12.2	14.3	15.2	14.1	11.8	10.8	36.7	14.74
Katha	17.2	6.8	20.2	15.3	18.3	13.6	18.2	12.2	16.2	44.6	18.26
Banarasi Karaka	13.8	2.5	21.5	16.6	18.2	16.2	12.8	14.6	15.2	39.5	17.09
Banarasi Pebandi	9.2	1.2	17.3	18.2	15.2	16.2	10.2	16.2	14.5	35.8	15.40
Aliganj	17.2	2.8	15.5	10.2	14.2	13.2	16.8	13.6	11.0	35.4	14.99
Kaithali	13.7	2.4	23.6	15.3	17.3	15.1	14.0	14.6	14.6	30.1	16.07
Chhuhara	12.1	6.2	33.1	13.2	13.8	14.1	13.2	12.2	15.1	31.3	16.43
Maharwali	14.2	**13.2**	22.2	**16.2**	19.0	17.6	15.6	**14.1**	**17.0**	38.1	18.72
Thornless	16.2	4.2	17.8	8.2	11.2	12.2	15.2	10.4	7.1	35	13.75
Seb	25.4	8.6	31.2	15.2	16.2	15.2	26.5	12.5	14.2	41.2	**20.62**
Sanaur-5	21.2	3.7	29.2	13.2	16.2	14.8	22.8	11.0	14.8	35.9	18.28
Kali	19.1	6.2	22.8	12.5	13.5	14.1	18.2	12.4	11.5	28.1	15.84
Dandan	15.8	3.8	33.3	14.2	16.2	15.2	12.6	13.2	16.0	32.1	17.24
Umran	17.2	**9.4**	29.1	**16.2**	18.2	14.8	16.2	**14.8**	13.8	42.2	**19.19**
Gola	28.3	**14.3**	46.8	27.3	32.3	28.8	27.2	**26.2**	**23.2**	60.1	**31.45**
Jogia	13.1	2.4	32.5	11.2	21.2	22.0	10.2	12.5	12.0	42.4	17.95
Illaichi	15.7	**11.9**	21.8	**15.6**	19.6	20.2	13.8	**11.6**	**16.7**	31.2	17.81
Tikadi	22.8	**11.2**	23.4	16.7	15.7	16.0	19.6	9.3	12.2	29.0	17.59
Mean	18.01	5.85	26.05	15.22	17.68	16.71	17.85	13.95	14.71	37.86	18.39
CD(P=0.05)	4.41	1.01	2.93	1.64	1.67	1.47	1.88	2.11	1.32	3.11	

Table 3: R squire and regression equation for fruit yield of *ber* varieties (2001-10) and chi-square analysis.

S.No.	Name of cultivars	R^2	Regression equation	Chi-Square
1.	CAZRI Gola	0.970	Y= -2+0.114x	0.416
2.	Rashmi	0.835	Y= -0.30+0.045x	0.390
3.	Bagwadi	0.794	Y=1.53+0.047x	0.641
4.	Mundia	0.541	Y=9.47+0.038x	0.021
5.	ZG-3	0.655	Y=0.334+0.0464x	0.107
6.	Katha	0.646	Y=1.727+0.053x	0.126
7.	Banarasi Karaka	0.559	Y=2.821+0.045x	0.016
8.	Banarasi Pebandi	0.374	Y=4.33+0.035x	0.044
9.	Aliganj	0.777	Y=-0.02+0.048x	0.006
10.	Kaithali	0.633	Y=4.409+0.037x	0.002
11.	Chhuhara	0.493	Y=3.92+0.040x	0.000
12.	Maharwali	0.443	Y=8.72+0.032x	0.000
13.	Thornless	0.794	Y=-1.95+0.050x	0.012
14.	Seb	0.903	Y=0.846+0.063x	0.132
15.	Sanaur-5	0.913	Y=0.010+0.058x	0.418
16.	Kali	0.930	Y=3.33+0.040x	0.001
17.	Dandan	0.567	Y=3.44+0.040x	0.001
18.	Umran	0.625	Y=3.73+0.049x	0.001
19.	Gola	0.655	Y=9.983+0.069x	0.172
20.	Jogia	0.521	Y=0.303+0.056x	0.004
21.	Illaichi	0.456	Y=9.73+0.026x	0.005
22.	Tikadi	0.836	Y=6.05+037x	0.141

ZG-3, Kali, Jogia and Rashmi were almost free from cracking. Fruit cracking is also severe problem in many other fruits such as litchi, pomegranate, sour lime and sweet cherry etc. Significant differences in fruit cracking severity between different pomegranate cultivars has been reported by Yuan *et al*. (2012) and in litchi by Mandal and Mitra (2014).

Table 4: Fruit cracking in different varieties of *ber* as a result sudden rain fall during 2011.

S. No.	Varieties	Per cent cracking	Mean weight of cracked fruit	Specific gravity ofcracked fruit
1.	CAZRI Gola	10	15.84	0.99
2.	Tikadi	6	3.31	1.1
3.	Banarasi Pebandi	30	8.19	0.98
4.	Aliganj	50	7.3	0.97
5.	Kaithali	15	6.07	1.01
6.	Chuhara	4	10.09	1.0
7.	Maharwali	10	9.70	0.97
8.	Thornless	13.33	6.88	0.99
9.	Seb	60	12.12	0.93
10.	Sanaur-5	4	13.97	0.99
11.	Dandan	10	12.91	0.95
12.	Gola	10	12.26	0.94

Regression analysis

Based on mean fruit yield data of 22 cultivars over a period of ten years (2001-2010), regression equation

Table 5: Effect of rescheduling pruning on flowering fruiting and yield of *ber* var.Gola (2010-11).

Pruningdate	Plant height(m)	Canopy area(m^2)	% fruit set	% fruit drop	Fruit weight(g)	Fruit length (mm)	Fruit breadth (mm)	Pulp: stone ratio	TSS (^{0}Brix)	Fruit yield (kg plant^{-1})
3.5.10	3.89	21.08	4.3	59.35	18.83	33.6	32.53	9.63	21.36	81.36
13.5.10	4.08	19.2	3.81	65.06	17.73	32.9	32.26	9.33	23.55	83.04
23.5.10	3.8	23.58	3.83	55.45	20.43	34.0	33.13	9.73	21.88	83.74
3.6.10	3.96	22.89	4.32	52.48	23.30	34.8	33.86	10.10	22.33	96.59
13.6.10	4.14	25.05	3.65	56.82	20.33	35.13	34.3	10.66	21.55	91.70
23.6.10	3.74	26.97	4.30	60.36	20.9	33.46	33.3	10.30	22.77	94.25
3.7.10	3.75	20.41	3.57	54.07	17.00	33.3	32.86	9.50	21.38	88.87
CD(P=0.05)	NS	2.46	0.51	5.79	2.41	NS	0.81	0.72	NS	7.90

was developed in respect to each variety which could be used to predict the fruit yield of any variety based upon quantum of annual rain fall (Table 3). The varieties CAZRI Gola, Rashmi, Seb, Sanaur-5, Kali and Tikadi recorded R^2 value of >0.8 which showed more responsiveness to rainfall, whereas the remaining varieties recorded R^2 value of <0.8 indicating their less dependence on rain fall. The differences between predicted yield and actual fruit yield were found to be non-significant as validated by chi-squire test (Table 3). This appears to be quite evident as other experimental conditions including input application and cultural practices were constant except rainfall and minor variation in weather parameters. Fluctuations in weather parameters do affect the flowering and fruiting but here the variation due to these parameters might have been insignificant. Gupta *et al.,* 2013 attempted forecasting of yield and yield contributing character in *ber* var. Gola, Muria Murhera, Sandhura Narnaul and Katha Phal under south western region of Punjab. However, they found November to March months as most sensitive period for fruit yield. Kumar *et al.* (2006) found positive correlation between total rainfall during the sprouting stage with fruit yield and quality, while rainfall during the flowering stage was negatively correlated with these parameters in *ber* based horti-pastoral system under rainfed conditions.

Rescheduling of pruning as coping strategy

The time of pruning in summer determines flowering and fruit maturity times in *ber*. Generally, pruning is done in first fortnight of May which results in flowering during August-September and fruit maturity during December-February depending upon variety. In variety Gola if pruning is done in middle of May, the fruits start maturing in the last week of December. Increase in temperature and decrease relative humidity during October-November in decade 2001-2010 resulted in more flower and fruit drop and the resultant decrease in total fruit yield. However, this cannot be generalized as the temperature and relative humidity change little bit every year. Significant differences in total fruit yield recorded on the trees pruned during May and June could be seen from Table 5. If pruning is delayed by a month, i.e. from May to June, the fruit set cum development will get delayed by about 1-2 weeks and thus shifting warmer and less humid period to relatively favorable period during second half of October to November, which might favour more fruit set and/less fruit drop or both and resultant higher fruit yield (Table 5). However, this may also lead to delay in fruit maturity by a weak. The early pruning in *ber* advance the bud sprouting, flowering and improved the fruit yield and quality (Sandhu *et al.,* 1992). However, under the changing climate in arid zone delaying of pruning by 15-30 days may be helpful in getting higher fruit set/ fruit yield due to shift in flowering /fruit setting to favourable weather with respect to temperature and humidity conditions.

CONCLUSION

The study revealed that different jujube varieties responded differently to natural climatic variability specially to rise in temperature and decline in relative humidity at the time of flowering and fruit setting. The varieties also showed significant variation in their response to rainfall at the time of fruit maturity and the resultant fruit cracking**.** The varieties Gola, CAZRI-Gola, Mundia, Maharvali, Illaichi and Tikadi maintained higher fruit yield under drought and low rainfall years and these can be recommended for rainfed condition. Pruning should be done in the month of June every year. The regression model developed based upon two decades rainfall data could be used to predict fruit yield of a variety based upon rainfall as validated by chi-square test.

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REFERENCES

Chaturvedi, R.K., Joshi, J., Jayaraman, M., Bala, G. and Ravindranath, N. H. (2012). Multimodel climate change projection for India under representative concentration pathways. *Current Sci*., 103(7): 1-12.

Gupta, N., Gill, K.K. and Ritu Babuta (2013). Forecasting ber yield and yield contributing characters-An agrometeorological approach. *Int. J. Agric. Food Sci. Tech*., 4(5):397-400.

IPCC (2007). Climate Change-Impacts, Adaptation and Vulnerability. Report of Working Group-II, Contributions to the Inter-governmental Panel on Climate Change. Fourth Assessment Report. IPCC, 23 p.

Kumar, S., Singh, J.B. and Ram, S.N. (2006). Influence of pruning and weather on productivity of *ber*-based horti-pastoral system in rainfed conditions. *Indian J. Hort*., 63(3): 260-263.

Lonergan S. (1998). Climate warming and India. In: Dinar A., Mendelsontin R. Evenson R., (Editors). Measuring the Impacts of Climate Change on Indian Agriculture. World Bank Technical Report No. 402. Washington DC, USA.

Mandal, D. and Mitra, S.K. (2014). Relationship of fruit calcium content, fruit pressure at maturity and tubercle density with cracking and sun-burning in fifteen litchi cultivars of West Bengal, India. *Acta Horticulturae,* 1029: 209-214.

Pareek, O.P. (2001). Ber, International Centre for Underutilised Crops,Southampton, UK.

Rupakumar, K., Sahai, A. K., Krishnakumar, K., Patwardhan, S.K., Mishra, P.K. Revadkar, J.V., Kamala, K. and Pant, G.B. (2006). High resolution climate change scenarios for India for the 21st century. *Current Sci*., 90: 334-345.

Sandhu, A.S., Minhas, P.P.S. and Grewal, G.P.S. (1992). Influence of time of pruning on growth, flowering, fruit setting and fruit quality of Umran ber(*Zizyphus mauritiana* Lam.) *Haryana J. Hort. Sci*., 21(1-2): 1-5.

Sharma, S. K. and Chauhan, R. (2011). Climate change research initiative: Indian network for climate change assessment. *Current Sci*., 101(3): 308-311.

Simon, G. (2006). Review on rain induced fruit cracking of sweet cherries (*Prunus avium* L.), its causes and the possibilities of prevention. *Int. J. Hort. Sci*., 12(3): 27-35

Singh, R.S.,Vashishtha, B.B. and Prasad, R.N. (1998). Micrometeorology of ber (*Ziziphus mauritiana* Lamk.) orchard grown under arid conditions. *Indian J. Hort*., 55 (2): 97-107.

Yuan, Z.H., Yin, Y.L., Feng, L.J.,Zhao, X.Q., Hou, L.F. and Zhang, Y.X. (2012). Evaluation of pomegranate bagging and fruit cracking in Shandong, China. *Acta Horticulturae,* 940:125-129.