J. Appl. Hort., 2(2):98-101, July-December, 2000

Flowering scenario in commercial cultivars of jujube (*Ziziphus mauritiana* Lamk.) under Indian arid ecosystem

Vishal Nath* and R. Bhargava

*National Research Centre for Arid Horticulture, Bikaner 334 006 (Rajasthan), *Present address: HARP, Plandu , PO-Rajaulatu, Ranchi- 10, INDIA*

Abstract

The flowering scenario of six commercial cultivars of Indian jujube (Gola, Kaithali, Banarsi Kadaka, Umran, Mundia and Seb) at six locations (Anantapur, Sardarkrushinagar, Jobner, Jodhpur, Bikaner and Hisar) distributed from south to north have been pooled for 5 years to explain the variation in flowering behaviour and to assess the possible factor responsible for flowering of these cultivars at different locations. Irrespective of cultivars, peak flowering in ber starts from 17th June and continues up to 22nd October in various parts of the country. In southern India, however, peak of flowering occurs between 17th June and 30th August in different cultivars whereas in north India, the peak blossoming starts by 27th August and completes by 22nd October in commercial cultivars of jujube. Our results demonstrate that flowering in ber is generally dependent upon temperature and relative humidity and particularly on difference in maximum and minimum temperature at various locations. The maximum temperature of 32.4 to 36.9°C and the minimum temperature of 20.7 to 25.3°C along with a temperature difference of 8.6 -13.3°C and morning relative humidity of 70.6 - 82.5 per cent prevailing continuously for at least one month have been found to induce profuse flowering in ber cultivars across the arid region. Since such climatic conditions occur at different time at different latitude and longitude therefore, the flowering scenario in different jujube cultivars varies at different locations of arid ecosystem.

Key words: *Ziziphus mauritana* Lamk., ber, Indian jujube, flowering time, meteorological parameters.

Introduction

Indian jujube (*Ziziphus mauritiana* Lamk.), which is commonly known as ber, is considered as 'Apple of Desert'. It is a multistress tolerant fruit crop which performs well under arid and semi arid ecosystem. Drought avoidance mechanisms in the plants particularly due to tendency of summer dormancy, deep root system and special leaf characters enables the production of high quality ber fruits under fragile arid ecosystem. During most water scarce period in the region, the ber plant sheds its leaves and becomes dormant which put forth new growth with the onset of rains during monsoon period. Pruning of plants at dormant stage induces vigorous new flush. Flowering in ber is a typical phenomenon, which generally occurs on the secondary, tertiary and terminal primary branches of current season's growth. Teaotia and Chauhan (1963) however reported that flower buds in ber were borne both on mature and current season's growth. Inflorescence in ber is cyme where 12-14 flowers are borne on the nodes in the axil of leaf (Vashishtha and Pareek, 1979). As characteristic feature, all the flowers do not dehisce at one time and the complete process generally takes 1-3 months period depending upon the genotypes and the existing climatic conditions (Pareek, 1983; Sharma and Kore, 1990).

Effect of climatic condition on growth and development of vegetable crops has also been reported by Woodward and Begg (1976) and Bunce (1984). The flowering scenario of some commercial cultivars of ber in Indian arid ecosystem has been reported in this paper. Attempt has also been made to correlate the flowering with environmental factors at different locations.

Materials and methods

The present study has been done on six commercial jujube cultivars *i.e.* Gola, Kaithali, Banarsi Kadaka, Umran, Mundia and Seb. Data on initiation, peak and end of flowering of these cultivars from different centres of All India Co-ordinated Research Project on Arid Zone Fruits (AICRP, AZF) and Germplasm Evaluation Programme at National Research Centre for Arid Horticulture (NRCAH), Bikaner have been analysed. Flowering and weather data for 5 year (1986-90) at Anantapur (14°39′N 77°42′E), Andhra Pradesh; Sardarkrushinagar (23°0′N 72°50′E), Gujarat; Jobner (27°1′N 75°50′E), Rajasthan; Jodhpur (26°23′N 73°08′E), Rajasthan and Hisar (28°02′N 73°18′E), Haryana have been compiled for the analysis. For Bikaner (29°12′N 75°45′E), Rajasthan, data of 1994-98 have been analysed.

Data on initiation, peak and end of flowering at various stations over the years have been tabulated and a range of dates for each stage have been drawn. The mean day value for each stage has been calculated from the respective 5 year's pooled data. The minimum and maximum temperature (°C) and per cent morning and evening relative humidity (RH) over the years at various locations have been computed from the data provide by the respective stations. The temperature difference has been calculated by simple subtraction of mean minimum temperature from the mean maximum temperature.

Results and discussion

Flowering in ber is a long process which starts from forth week of May in southern peninsula and continues up to end of November

north-western part of the country. Flowering time in ber increases with the increase in latitude from south to north. Irrespective of cultivar, flowering process is completed by 5th September at Anantpur in Andhra Pradesh whereas it continues up to 29th November at Hisar in Haryana. In Rajasthan however, the process starts around 24th July and completes by 10th November. Vashishtha and Pareek (1979) reported that flowering in ber cultivars takes place during August-October with a peak in September under Jodhpur conditions whereas, Pareek (1983) mentioned that flowering in ber begins in July reaching its peak in September with some sporadic flowers appearing till the middle of December in western Rajasthan. Flowering scenario of some commercial cultivars of Indian jujube have been presented and discussed here.

Gola: Flowering in Gola cultivar of ber starts from 25th May at Anantapur and continues up to 25th November at Sardarkrushinagar (Fig.1). Peak flowering takes place on 30th July at Anantapur, 30th September at Sardarkrushinagar, 25th September at Jobner, 10th September at Jodhpur, 25th September at Bikaner and 10th October at Hisar. Data presented in Table 1a and b reveal that a minimum (22.2-25.3°C) and maximum (33.7-36.8°C) temperature range (23.8 and 33.7°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar, 22.2 and 34.0°C at Jobner, 24.9 and 35.9°C at Jodhpur, 25.3 and 36.8°C at Bikaner and 22.6 and 35.3°C at Hisar) along with respective RH favours the peak flowering. It is apparent from Table 2 that a range of temperature difference between 9.1 to 13.3°C continuously for one month along with 71.6 to 80.3 per cent morning RH is congenial for profuse flowering of Gola ber throughout the arid part of the country.

Kaithali: Flowering in Kaithali cultivar of ber starts from 30th June at Anantapur in southern India and continues up to 29th November at Hisar in north western India (Fig.1). Peak flowering in Kaithali takes place on 30th August at Anantapur, 22nd September at Sardarkrushinagar, 5th October at Jobner, 22nd September at Jodhpur, 14th October at Bikaner and 30th September at Hisar. Data presented in Table 1a and b reveal that a minimum (20.7-25.3°C) and maximum (33.3-36.8°C) temperature range (23.3 and 33.3°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar, 22.2 and 34.0°C at Jobner, 20.7 and 36.7°C at Jodhpur, 25.3 and 36.8°C at Bikaner and 22.6 and 35.3°C at Hisar) along with respective RH favours the peak flowering. It is apparent from the Table 2 that a range of temperature difference between 7.6 to 11.5°C continuously for one month along with 71.9 to 81.2 per cent morning RH is congenial for profuse flowering of Kaithali cultivar of ber throughout the arid region of the country.

Banarsi Kadaka: Flowering in Banarsi Kadaka starts from 10th June at Anantapur in southern peninsula and continues up to 23rd November at Sardarkrushinagar in western part of the country (Fig. 1). Peak flowering in this cultivar takes place on 17th June at Anantapur, 28th September at Sardarkrushinagar, 5th October at Jobner, 25th September at Jodhpur, 20th October at Bikaner and 30th September at Hisar. Singh *et al.* (1970) have also reported that under Hisar conditions, Banarsi Kadaka flowered from September to November with 83 per cent blossoming during October. Data presented in Table 1a and b reveal that a minimum (22.2-24.9°C) and maximum (34.0-35.9°C) temperature range (24.7 and 35.9°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar, 22.2 and 34.0°C at Jobner, 24.9 and 35.9°C at Jodhpur, 21.4 and 35.4°C at Bikaner and 22.6 and 35.3°C at Hisar) along with respective RH favours the peak of blossoming in Banarsi Kadaka. It is clear from Table 2 that a range of temperature difference between 11.0 to 13.3°C continuously for one month along with 70.6 to 80.3 per cent morning RH is congenial for profuse flowering in Banarsi Kadaka cultivar of ber throughout the arid belt.

Umran: Blossoming in Umran cultivar of ber starts from 2nd June at Anantapur and continues up to 25th November at Hisar. Peak of blossoming occurs on 5th August at Anantapur, 25th September at Sardarkrushinagar, 5th October at Jobner, 18th September at Jodhpur, 1st October at Bikaner and 10th October at Hisar (Fig. 1). Perusal of data presented in Table 1a and b reveal that a minimum (22.2-25.3°C) and maximum (33.7-36.8°C) temperature range 23.8 and 33.7°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar,

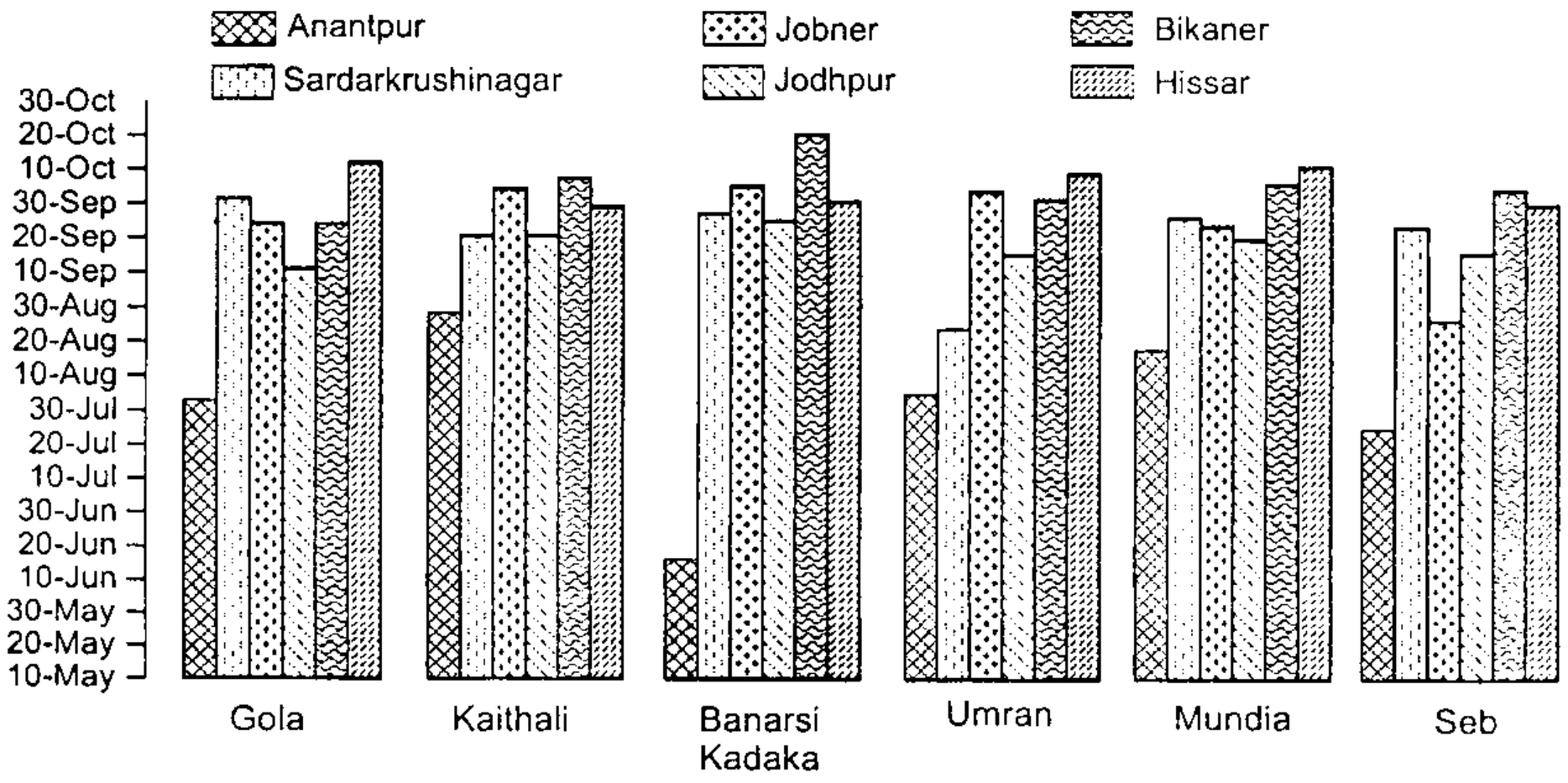

Fig. 1: Peak flowering in ber cultivars at different geographical locations

22.2 and 34.0°C at Jobner, 24.9 and 35.9°C at Jodhpur, 25.3 and 36.8°C at Bikaner and 22.6 and 35.3°C at Hisar) along with respective RH favours the peak flowering in Umran. Perusal of data presented in Table 2 reveal that a range of temperature difference between 9.9 to 13.3°C continuously for one month along with morning RH of 71.9 to 80.3 per cent favours the profuse flowering in Umran cultivar of ber throughout the Indian arid zone.

Mundia: Flowering in Mundia cultivar of ber starts from 30th June at Anantapur in Andhra Pradesh and continues up to 30th November at Sardarkrushinagar in Gujarat. Figure 1 demonstrate that pea of blossoming takes place on 18th August at Anantapur, 25th September at Sardarkrushinagar, 22nd September at Jobner, 19th September at Jodhpur, 5th October at Bikaner and 10th October at Hisar. Data presented in Table 1a and b reveal that a minimum (22.2-25.3°C) and maximum (33.3-36.9°C) temperature range (23.3 and 33.3°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar, 22.2 and 34.0°C at Jobner, 24.9 and 35.9°C at Jodhpur, 25.3 and 36.9°C at Bikaner and 22.6 and 35.3°C at Hisar) along with respective RH favours the peak of flowering in this cultivar. Perusal

Table 1(a). Minimum and maximum temperature (°C) at different locations during 1986-90

Months	Minimum temperature (°C)						Maximum temperature (°C)					
	ANP	SKN	JOB	JDP	BKN*	HIS	ANP	SKN	JOB	JDP	BKN*	HIS
January	17.7	9.5	6.2	11.7	7.3	4.5	30.5	27.8	23.3	25.4	23.2	20.4
February	19.9	12.0	8.9	12.9	10.8	6.7	33.6	29.5	25.2	27.8	27.2	23.6
March	22.4	16.5	13.1	17.1	16.3	11.8	37.4	34.5	30.3	31.9	32.4	29.9
April	25.7	21.5	18.6	24.9	21.3	17.1	39.4	37.9	37.6	37.2	37.7	35.6
May	26.2	25.1	24.7	26.7	25.5	25.5	39.7	41.4	40.3	41.2	42.5	41.2
June	24.7	27.5	26.7	27.2	27.9	27.0	35.9	38.6	39.3	39.8	40.6	39.5
July	23.8	26.1	26.0	26.9	28.2	26.5	33.7	34.5	33.5	36.2	38.1	36.2
August	23.3	25.1	23.8	25.7	27.0	26.0	33.3	32.7	32.4	34.8	36.9	35.1
September	23.3	24.2	22.2	24.9	25.3	22.6	33.5	35.4	34.0	35.9	36.8	35.3
October	21.7	18.9	16.1	20.7	21.4	16.2	32.4	36.1	33.4	36.7	35.4	34.8
November	19.1	13.4	9.6	16.0	12.2	11.6	30.8	31.7	27.8	32.0	29.8	28.7
December	18.0	11.8	5.6	10.7	7.1	5.7	30.1	28.0	21.8	26.2	24.5	23.4

Table 1(b). Morning and evening relative humidity (RH) at different locations during 1986-90

Months	Morning relative humidity (%)						Evening relative humidity (%)					
	ANP	SKN	JOB	JDP	BKN*	HIS	ANP	SKN	JOB	JDP	BKN*	HIS
January	83.8	66.5	87.7	52.0	67.9	87.0	46.0	25.9	46.9	21.8	28.0	42.8
February	73.0	61.0	80.3	50.0	63.2	83.7	35.0	29.8	36.2	16.8	23.3	35.0
March	60.2	58.4	76.2	42.0	55.9	80.1	22.8	20.1	36.8	15.8	21.1	33.0
April	58.8	49.0	50.9	31.4	44.6	66.0	23.0	17.3	28.1	11.2	16.9	29.0
May	64.6	68.1	59.6	47.0	44.8	49.6	27.0	23.6	31.1	16.8	18.9	20.5
June	70.6	73.2	66.9	60.0	49.5	56.0	39.4	39.5	34.0	28.6	29.8	33.0
July	78.2	82.0	79.8	76.0	64.4	72.6	46.8	56.4	45.5	47.8	43.1	55.8
August	81.2	86.0	82.5	82.0	71.6	80.6	49.2	60.6	58.2	54.2	43.6	57.3
September	80.2	80.3	78.9	75.0	71.9	79.6	48.6	45.7	46.7	41.6	40.5	47.8
October	81.2	61.4	70.5	49.2	63.9	77.1	49.0	22.0	33.8	18.0	39.8	32.3
November	82.2	59.2	73.8	44.8	68.9	65.8	46.2	23.3	27.9	16.6	33.6	29.8
December	84.4	63.1	76.1	49.6	72.9	82.4	51.0	24.3	33.0	21.6	38.1	37.3

Table 2. Temperature difference (°C) and morning RH (%) at different locations during 1986-90

Months	Temperature difference (°C)						Morning RH (%)					
	ANP	SKN	JOB	JDP	BKN*	HIS	ANP	SKN	JOB	JDP	BKN*	HIS
January	12.8	18.3	17.1	13.7	15.9	15.9	83.8	66.5	87.7	52.0	67.9	87.0
February	13.7	17.5	16.3	14.9	16.4	16.9	73.0	61.0	80.3	50.0	62.3	83.7
March	15.0	18.0	17.2	14.8	16.1	18.1	60.2	58.4	76.2	42.0	55.9	80.1
April	13.7	16.4	19.0	12.1	16.4	18.5	58.8	49.0	50.9	31.4	44.6	66.0
May	13.5	16.3	15.6	14.3	17.0	15.7	64.6	68.1	59.6	47.0	44.8	49.6
June	11.2	11.1	12.6	12.6	12.7	12.5	70.6	73.2	66.9	60.0	49.5	56.0
July	9.9	8.4	7.5	9.3	9.9	9.7	78.2	82.0	79.8	76.0	64.4	72.6
August	10.0	7.6	8.6	9.1	9.9	9.1	81.2	86.0	82.5	82.0	71.6	80.6
September	10.2	11.2	11.8	11.0	11.5	13.3	80.2	80.3	78.9	75.0	71.9	79.6
October	10.7	17.2	17.3	16.0	16.8	18.6	81.2	61.4	70.5	49.2	63.9	77.1
November	11.7	18.3	18.2	16.0	17.6	17.1	82.2	59.2	73.8	44.8	68.9	65.8
December	12.1	16.2	16.2	15.5	17.4	17.7	84.4	63.1	76.1	49.6	72.9	82.4

ANP-Anantapur, SKN- Sardarkrushinagar, JOB- Jobner, JDP- Jodhpur, BKN- Bikaner, HIS- Hisar

*Data of 1994-98 have been analysed.

of data in Table 2 reveal that a range of temperature difference between 10.0 to 13.3°C along with 71.9 to 81.2 per cent morning RH continuously for one month favours peak flowering in Mundia cultivar of ber in arid part of the country.

Seb: Flowering in Seb ber starts from 25th May at Anantapur in southern India and continues up to 15th November at Sardarkrushinagar in western India (Fig. 1). Peak of flowering takes place on 25th July at Anantapur, 22nd September at Sardarkrushinagar, 27th August at Jobner, 18th September at Jodhpur, 5th October at Bikaner and 30th September at Hisar. Data presented in Table 1a and b reveal that a minimum (22.6-25.3 °C) and maximum (32.4-36.8°C) temperature range 23.3 and 33.3°C at Anantapur, 24.2 and 35.4°C at Sardarkrushinagar, 23.8 and 32.4°C at Jobner, 24.9 and 35.9°C at Jodhpur, 25.3 and 36.8°C at Bikaner and 22.6 and 35.3°C at Hisar along with respective RH favours the peak of flowering in Seb cultivar of ber. It is clear from Table 2 that a range of temperature difference between 8.6 to 13.3°C continuously for one month along with 71.9 to 82.5 per cent morning RH favours the profuse blossoming in Seb cultivar of ber throughout the arid region of the country.

The above observations demonstrate that ber cultivars differ in time of blossoming at different geographical locations in India (Fig 1). Pareek (1983) also confirmed that duration of flowering in ber is prolonged and the time of blossoming largely depends on the climatic conditions of particular location. Accordingly, an attempt has been made to correlate the flowering in ber with the prevailing climatic conditions of each location. In light of the above facts, summary Table 3 presents the range of maximum and minimum temperature, temperature difference and morning relative humidity (one month before the peak of flowering) for different cultivars. Perusal of table reveals that ber flowers profusely when the maximum temperature ranges between 32.4-36.9°C and minimum between 20.7-25.7°C along with a temperature difference of 8.6-13.3°C and morning relative humidity of 70.6-82.5% for at least one month. It is also apparent from the data that the requirement of these climatic conditions are almost identical in all the cultivars. Vashishtha and Pareek (1979) reported that the morning temperature of 23.8°C (8.00 am) and afternoon temperature of 29.8°C (2.00 pm) along with 71-97% relative humidity favours the maximum flowering in ber cultivars under Jodhpur condition. Owing to moderate climate in southern part, the required conditions for the peak flowering of jujube cultivars are achieved much earlier whereas in northern India, this condition is achieved during monsoon / post monsoon period. This amply explains the difference in flowering time of ber cultivars in north and south India. For instance, at Anantapur the peak flowering takes place during July-August when nearly all climatic conditions are fulfilled whereas in northern part this situation arises during September-October, which is the peak flowering period for ber cultivars in this region. Thus, from the foregoing account it can be argued that flowering in ber is a function of interaction between temperature and relative humidity. The profuse flowering takes place, if the maximum temperature ranges between 32.4-36.9°C with minimum temperature 20.7-25.3°C. It should also posses morning RH of 70.6-82.5% along with temperature difference between 8.6-13.3°C. Since these situations appears during different months in northern and southern India, hence, the flowering period varies in different part of the arid zone.

Table 3. Environmental parameters congenial for peak of flowering in jujube cultivars

Cultivars	Max. Temp. (°C)	Min. Temp. (°C)	Temp. Difference (°C) (one month before)	Morning RH(%) (one month before)
Gola	33.7-36.8	22.2-25.3	9.1-13.3	71.6-80.3
Kaithali	33.3-36.8	20.7-25.3	7.6-11.5	71.9-81.2
Banarsi Kadaka	34.0-35.9	22.2-24.9	11.0-13.3	70.6-80.3
Umran	33.7-36.8	22.2-25.3	9.9-13.3	71.9-80.3
Mundia	33.3-36.9	22.2-25.3	10.0-13.3	71.9-81.2
Seb	32.4-36.8	22.6-25.3	8.6-13.3	71.9-82.5
Mean	32.4-36.9	20.7-25.3	7.6-13.3	70.6-82.5

Acknowledgement

We are thankful to PC, AICRP(AZF) and Head of various stations for providing information. Thanks are also to Dr B.B. Vashishtha and Shri B.R. Khatri for their help in documentation.

References

Bunce, J.A., 1984. Effect of humidity on photosynthesis. *J. Expt. Bot. J.*, 35: 1245-1251.

Pareek, O.P., 1983. The Ber. Indian Council of Agricultural Research. New Delhi, 71p.

Sharma, V.P. and V.N. Kore, 1990. Ber. *In*: Fruits- tropical and subtropical. (Eds T.K. Bose and S.K. Mitra). Naya Prokash Calcutta, pp.592-615.

Singh, D., J.C. Bakhshi and K. Singh, 1970. Flowering and fruiting behaviour of ber variety Banarsi Kadaka (*Ziziphus mauritana* Lamk.). *Punjab Hort. J.*, 10: 21-28.

Teaotia, S.S. and R.S. Chauhan, 1963. Flowering, pollination, fruit set and fruit drop studies in ber (*Ziziphus mauritiana* Lamk.) I. Floral biology. *Punjab Hort. J.*, 3: 60-70.

Vashishtha, B.B. and O.P. Pareek, 1979. Flower morphology, fruit set and fruit drop in some ber (*Ziziphus mauritana* Lamk.) cultivars. *Annals of Arid Zone.*, 18(3): 165-169.

Woodward, R.G. and J.E. Begg, 1976. The effect of atmospheric humidity on the yield of soybean. *Aust. J. Agric. Res.*, 27: 501-508.

Potato, *Global Research & Development* - Volume II, 1139-1143
Editors: S.M. Paul Khurana, G.S. Shekhawat, S.K. Pandey and B.P. Singh ©2002 Indian Potato Association, Shimla

Effect of physiological age of seed tubers on growth and yield of potato

V.K. Dua[1] and R. Bhargava[2]

ABSTRACT Experiment conducted during 1994-1995 to study the effect of ageing of potato at Shimla revealed that the number of sprouts, length of longest sprout and total length of sprouts per tuber increased linearly with increasing physiological age. Increased physiological age of seed tubers also helped in early emergence and early canopy development. At the optimum date of harvesting, tuber yield from the seed tubers of 1200-1500 degree-days (DD) was higher than that of the seed tubers stored at ambient temperature. Potato crop raised with the seed tubers of 1500 DD could be harvested before the optimum date without any yield reduction.

INTRODUCTION

The practice of planting pre-sprouted seed tubers has been in vogue for a very long time. The seed tubers and sprouts undergo considerable modification during the sprouting period and the plants from the pre-sprouted seed tubers emerge earlier than those from the unsprouted one resulting in the partial displacement of the vegetative period (Toosey, 1964). Sprout growth depends on pre-planting environment of seed tubers, which are physiological in nature, and lately have been summarised under the term "physiological age". Toosey (1963) has defined the physiological age as "the physiological state of a tuber at any given time which is illustrated by the visible sprout growth". Since the rate of sprout growth is linearly related to temperature at which seed tubers are stored, the use of accumulated degree-days (DD) from the dormancy breaking is used as a quantitative measure of physiological age (Allen *et al.*, 1992).

Little information is available on the effect of physiological age of tubers on the growth and yield of potato crop grown in Shimla hills. Therefore, the present study was undertaken to study the effect of ageing of seed tubers on sprout growth and their subsequent effect on the growth and yield of potato crop.

MATERIALS AND METHODS

The medium sized well-chitted seed tubers of potato *cv.* Kufri Jyoti (*Solanum tuberosum* L.) were stored in a controlled temperature cabinet at 4 ± 1°C. These seed tubers were transferred to an illuminated controlled temperature chamber at 20 ± 1°C at different time intervals to obtain seed tubers of 5 different physiological ages (600, 900, 1200, 1500 and 1800 degree-days) at the time of planting. The accumulated degree-days were calculated using the following formula:

$$\text{Accumulated degree-days(DD)} = \sum_{1}^{n} (\text{Storage temp. in } ^\circ\text{C} - 4),$$

where n = number of days in storage after chitting.

---

[1]Central Potato Research Institute, Shimla-171 001, Himachal Pradesh
[2]Present address: National Research Centre for Arid Horticulture, Bikaner-343 003, Rajasthan

A base temperature of 4°C was used in the present study to calculate the accumulated degree-days since at this temperature limited sprout growth occurs. For control, one lot of seed tubers was also stored at ambient temperature (A.T.).

Experiment was planted at the Central Potato Research Institute, Shimla during 1994 and 1995. The soil of the experimental site was sandy loam in texture, slightly acidic in reaction (pH 6.1), medium in available nitrogen and high in available phosphorus and potassium. Planting was done in the last week of April during both the years. Experiment was laid out in factorial RBD with three replications. Treatments consisted of combination of seed tubers of 5 physiological ages plus 1 control and 3 dates of harvesting (Optimum date i.e. 15th September and 15 and 30 days before the optimum date). The seed tubers were planted at a spacing of 50 x 20 cm. A basal dose of 30 t FYM, 75 kg N, 100 kg P_2O_5 and 100 kg K_2O/ ha was applied at the time of planting, and another dose of 75 kg N/ha was applied at earthing up (40 days after planting) to all the plots. Standard practices were adopted for pests management.

At the time of planting, ten seed tubers were selected randomly from each treatment to record number and length of sprouts. Emergence count was taken on alternate days till complete emergence. For canopy cover percentage, a quadrate divided into 100 squares of 5 x 5 cm was placed at two places in each plot, and the number of squares with more than 50% canopy under it were counted and expressed as the percentage of total. The crop was harvested as per the treatments. The data obtained were pooled over the years for analyses using standard statistical procedures.

RESULTS AND DISCUSSION

Sprout growth: Number of sprouts, length of longest sprout and the total length of sprouts /tuber showed a close linear relationship with physiological age. The data were highly significant and showed that all these parameters were strongly correlated with physiological age (Fig.1). Kawakami (1952) has also reported that the rapidity of sprout growth increased with physiological age of the tubers. A similar relationship was also observed by Allen and O'Brien (1986), who concluded that the effect of pre-planting environment on sprout growth might be summarized by accumulated degree-days.

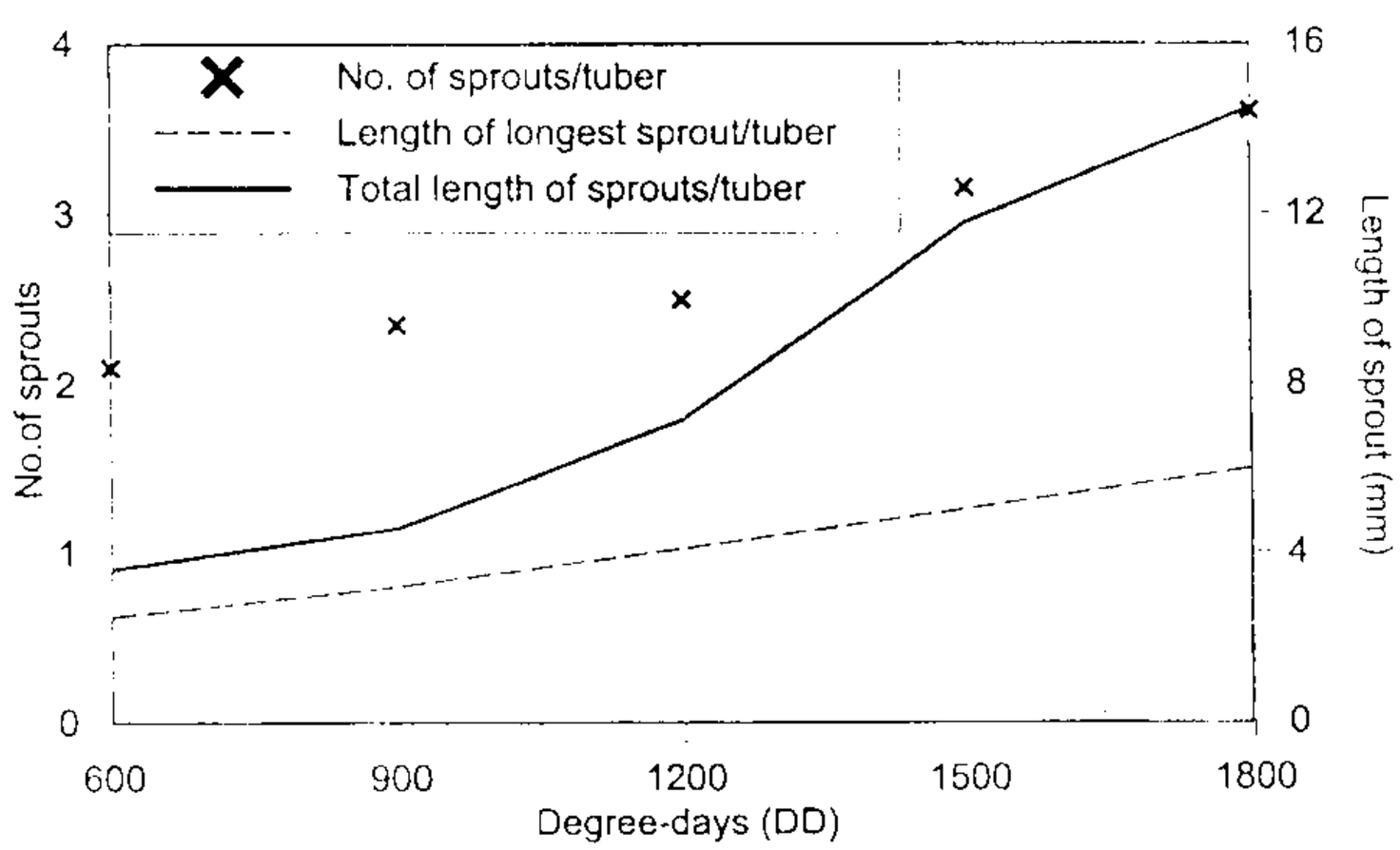

Fig.1. Influence of accumulated degree-days on no. of sprouts/tuber (y = 1.22+0.001x, r = 0.972**), length of longest sprout (mm)/ tuber (y = 0.63+0.003x, r = 0.998**) and total length of sprouts (mm)/tuber (y = (-)3.24+0.0096x, r = 0.979**)

Physiolo

Plant gr
from the
between
r = 0.99
after plar
A similar
seed tub
planting.
degree-d
and thes
temperat
of 900 D

Fig.2. Effec

Tuber yie
tuber yield
tuber yield
up to 120
significantl
tubers ind
tubers if pl
physiologic
and 'senile

The m
at par with
tubers of

Plant growth: Plants from physiologically older seed tubers displayed more rapid emergence than those from the physiologically younger seed tubers (Fig.2). A close positive linear relationship was observed between the percentage emergence and the accumulated degree-days at 17 days ($y = -0.78 + 0.027x$; $r = 0.997^{**}$), 19 days ($y = 17.33 + 0.025x$; $r = 0.997^{**}$) and 21 days ($y = 38.82 + 0.022x$; $r = 0.996^{**}$) after planting. However, this age-induced advantage got lost with the advancement of growth of the plant. A similar trend was also observed in the canopy development (Fig. 3). Plants from physiologically older seed tubers had a greater canopy coverage than those from the younger seed tubers up to 60 days after planting. Canopy cover percentage showed a significant positive linear relationship with accumulated degree-days at 40 days ($y = 4.96 + 0.017x$; $r = 0.992^{**}$) and 60 days ($y = 21.66 + 0.028x$; $r = 0.901^{*}$), and these age induced differences attenuated with further plant age. The seed tubers stored at ambient temperature (control) enjoyed approximately 750 DD, and closely resembled the growth of seed tubers of 900 DD in terms of emergence and canopy development.

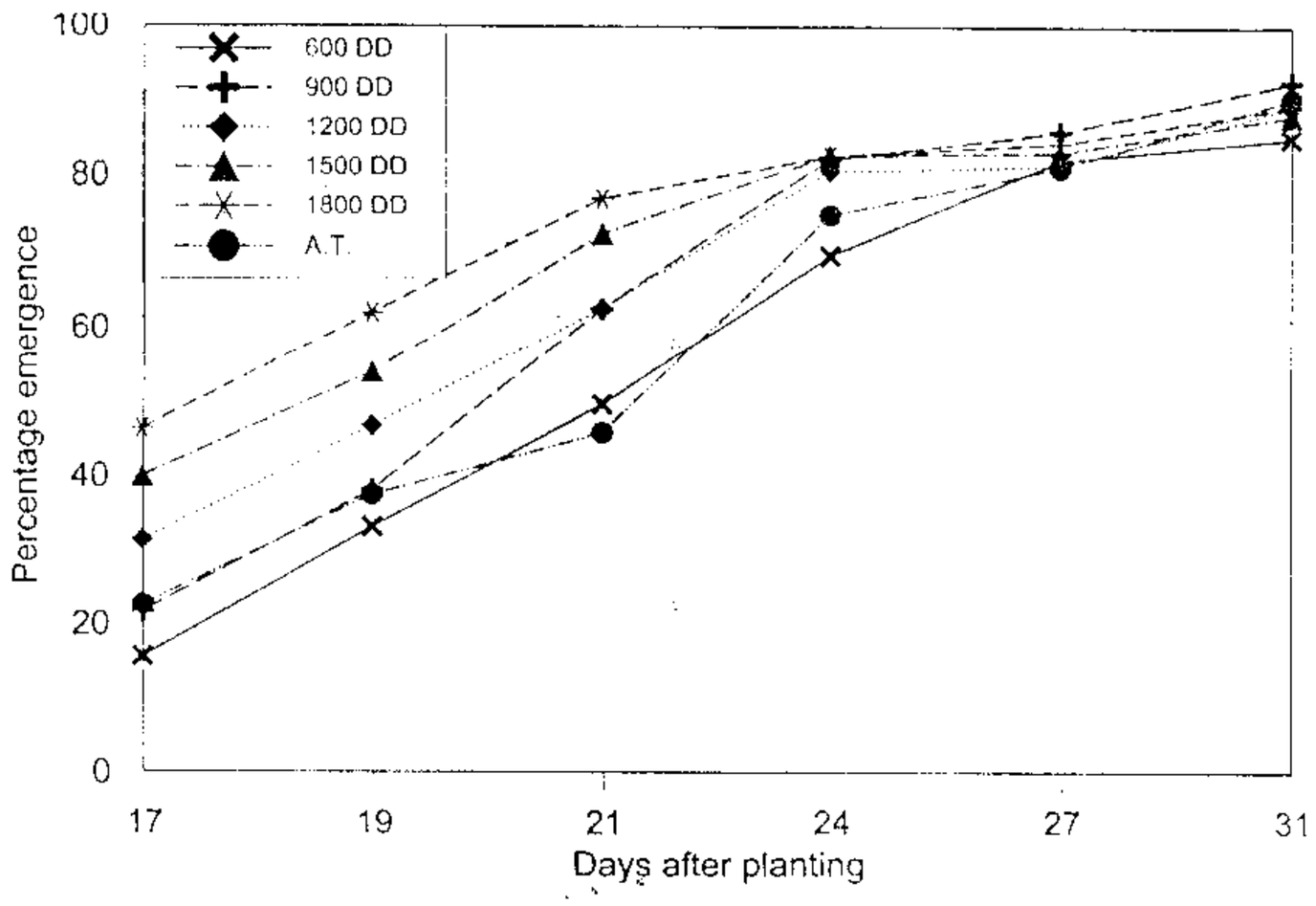

Fig.2. Effect of physiological age on percentage emergence

Tuber yield: The effect of physiological age, date of harvesting and their interaction was significant on tuber yield (Table 1). By advancing the harvesting date by 30 days, a significant reduction in the mean tuber yield was observed. The mean tuber yield increased significantly with increase in physiological age up to 1200 DD, and further increase to 1500 DD had no significant effect. However, yield decreased significantly with increasing physiological age from 1500 DD to 1800 DD. The lower yield from these tubers indicated that these tubers were physiologioally too old. Kawakami (1962) reported that seed tubers if planted at the proper age gave the highest yield. The reduction in yield is caused by improper physiological age due to 'physiological degeneration'-'juvenile degeneration', if the seed is too young, and 'senile degeneration' if the seed is too old.

The mean tuber yield with the seed tubers stored at ambient temperature (control) was statistically at par with that obtained with the seed tubers of 900 DD. The highest tuber yield was obtained with seed tubers of 1200 DD when harvested at the optimum date. The yield with this treatment was at par with

Table 1. Effect of physiological age of seed tubers on potato tuber yield (q/ha) at different dates of harvesting (Pooled for 1994 and 1995)

Physiological age (Degree days).	Date of harvesting: 30 days before optimum	15 days before optimum	Optimum date (15th Sept.)	Mean
600	50.8	68.2	114.3	77.8
900	72.4	98.0	126.8	90.1
1200	103.7	141.2	179.8	141.6
1500	98.0	165.7	177.9	147.2
1800	101.0	106.8	126.2	111.3
Control(A.T.)*	83.9	76.8	119.3	91.2
Mean	83.9	109.4	140.7	

C.D. at 5%	Physiological age	=	7.8
	Date of harvesting	=	11.0
	Age x Date	=	19.0

*A.T.= Ambient Temperature

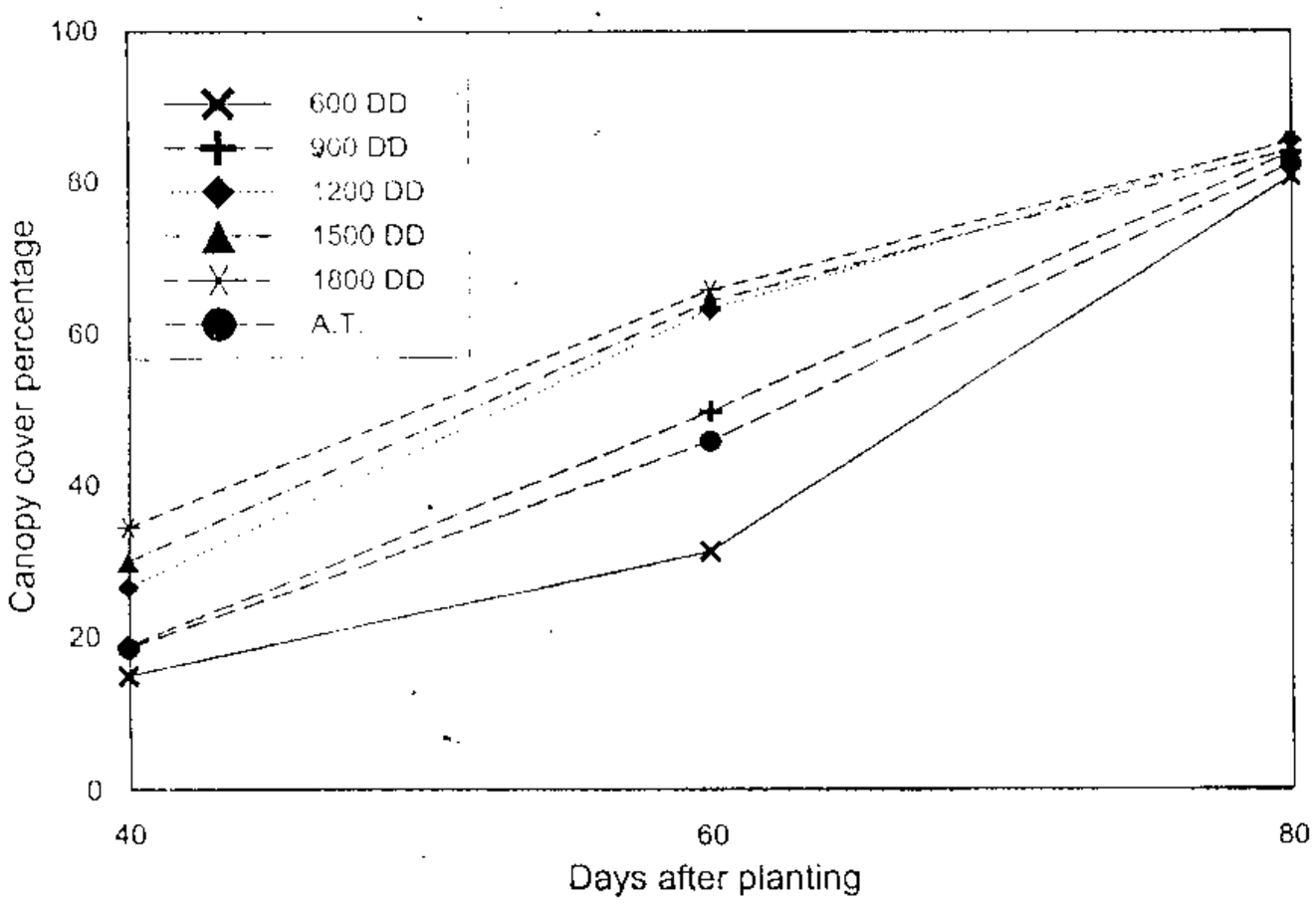

Fig.3. Effect of physiological age on canopy cover percentage

the yield of crop raised with the seed tubers of 1500 DD harvested at either optimum date or 15 days before the optimum date. Better effect of 1200-1500 DD seed tubers on tuber yield was associated with more rapid emergence and early growth which resulted in higher yield at early harvest (Figs. 2 and 3).

It may be concluded from the study that the physiological age of the seed tuber is correlated with sprout growth. Plant establishment from the physiologically older seed tuber is hastened. In the hills of

Physiological ag

Himachal Prad
perform better
potato crop rai
to the optimun
temperature a

REFERENCES

Allen E.J. and F
ological age

Allen E.J., P.J.
P.M. Harris)

Kawakami, K. 1
Sasayama 2

Kawakami, K. 1
49.

Toosey, R.D. 19
of the potat

Toosey, R.D. 19
I. Field Cro

ates of harvesting

Mean
77.8
9[illegible]
14[illegible]
147.2
111.3
91.2

Himachal Pradesh potato crop raised with the seed tubers of the physiological age of 1200 to 1500 DD perform better than the seed tubers stored at ambient temperature when harvested at optimum date. The potato crop raised with the seed tubers of physiological age of 1500 DD can be harvested 15 days earlier to the optimum date without yield loss, and still perform better than the seed tubers stored at ambient temperature and harvested at optimum date.

REFERENCES

Allen E.J. and P.J. O'Brien. 1996. The practical significance of accumulated day-degrees as a measure of physiological age of seed potato tubers. *Field crops Res.* **14**: 141-51.

Allen E.J., P.J. O'Brien and D. Firman. 1992. Seed tuber production and management. In *The Potato Crop* (Ed. P.M. Harris), pp. 247-91. Chapman and Hall, London.

Kawakami, K. 1952. Physiological aspects of potato seed tubers. *Reprinted from memoirs of Hyogo Agric. College. Sasayama* **2**: 1-114.

Kawakami, K. 1962. The physiological degeneration of potato seed tubers and its control. *European Potato J.* **5**: 40-49.

Toosey, R.D. 1963. The influence of sprout development at planting on subsequent growth and yield. In *The growth of the potato* (Eds. J.D. Ivins and F.L. Milthorpe). Butterworths, London.

Toosey, R.D. 1964. The pre-sprouting of seed potatoes: Factors affecting sprout growth and subsequent yield. Part I. *Field Crop Abstracts* **17**(3): 161-68.

days
d with
nd 3).

l with
lls of