Jour. Agric. Physics, Vol. 2, No. 1, pp. 29-32 (2002)

Effect of variable weather conditions on leaf area, biomass and seed yield in *Brassica spp.*

SUMANA ROY AND N.V.K.CHAKRAVARTY
Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Three cultivars of *Brassica* crop was sown on three dates at an interval of 15 days from the 1st October during two *rabi* seasons (2000-01 & 2001-02) with an aim to assess the influence of weather fluctuations on growth and yield. The leaf area index, above ground biomass, crop growth rates and pod growth rates were computed. The study revealed that all the growth parameters were significantly affected by changes in weather conditions brought about through delayed sowing. Pod formation and seed filling stages of late sown crop (1st November) experienced 6-11°C higher temperatures and 2-3 mm higher evaporative demand as compared to early sown crop (1st October). This probably was responsible for reduction in the dry matter partitioning and yields of late sown crop.

Key words: Weather fluctuation, pod formation, *Brassica* crop.

Introduction

Brassica, a major oilseed crop, is grown usually during *rabi* season. Variability in environmental factors mainly temperature and radiation causes substantial fluctuations in the production. Even under optimum and unlimited irrigated conditions, variation of temperature mainly influences the growth and development of this crop because most of the biological and physiological processes are known to be markedly affected by temperature (Prasad, 1989). *Brassica* being a cool season crop, 2-3°C higher temperature during pod formation and seed filling stage affects crop growth and yield significantly (Kar and Chakravarty, 2000). The time of sowing plays a key role in modifying the length of vegetative and reproductive phases in this crop (Krishnamurthy and Bhatnagar, 1998). An understanding of weather-yield relationship may help to determine proper time for sowing and specific agronomic practices to be followed in order to maximize yield. Hence an attempt has been made in this paper to report effects of variable weather conditions on the growth, leaf area index (LAI), above ground biomass production and yield of *Brassica* species.

Materials and Methods

A field experiment was conducted during the winter (*rabi*) seasons of 2000-01 and 2001-02 at research farm of Indian Agricultural Research Institute, New Delhi (28°35' N, 77°10' E and 228.16 m AMSL). The climate of the station is semiarid with dry hot summers and cold winters. The soil of this field belongs to the major soil group of Indo-Gangetic alluvium and is of sandy loam in nature belonging to the family of Typic ustocrepts.

Three *Brassica* cultivars (Agrani, Pusa Jaikisan and Varuna) differing in their maturity periods and canopy architecture were grown following the recommended package of practices. All the three cultivars were sown on three dates at 15 days interval starting from 1st October, to expose the same cultivar to different weather conditions at different phenological stages. For studying plant growth parameters like LAI, above ground biomass production and crop growth rate (CGR), plant samples were taken at 10 days interval. The leaf area was measured using leaf area meter (LI-3100). The leaf area index (LAI) was computed considering the number of plants per square meter was 30.

$$\text{LAI} = \frac{\text{Measured leaf area per plant (cm}^2\text{)}}{100 \text{ X } 100 \text{ (cm}^2\text{)}} \text{ X } 30$$

The above ground dry biomass production by the different cultivars was analyzed and the crop growth rate was computed using the relationship:

$$\text{CGR (g m}^{-2}\text{ day}^{-1}\text{)} = \frac{DW_2 - DW_1}{t_2 - t_1}$$

where, DW1 and DW2 are the above ground dry biomass of the crop from unit ground area (gm^{-2}) collected at days t_1 and t_2 ($t_2 > t_1$), respectively.

Results and Discussion

Weather and crop growth

The weather conditions of both seasons are presented in Fig.1. It was observed that in the first

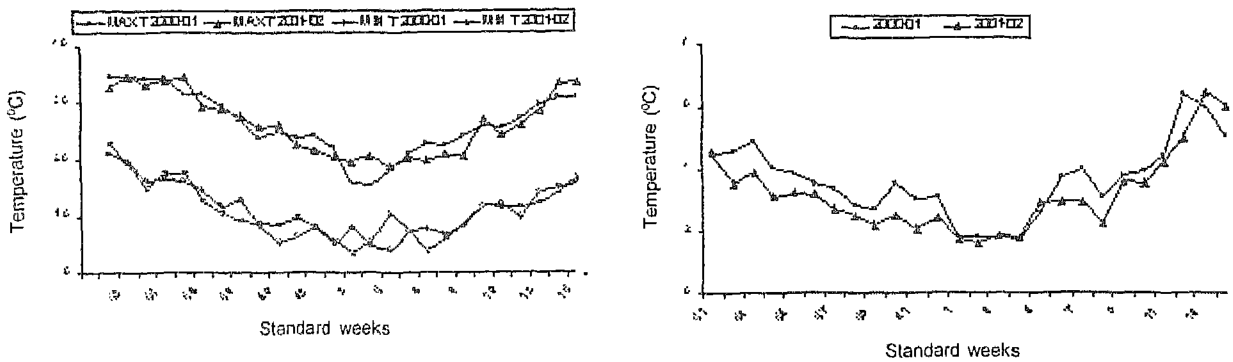

Fig. 1. Mean daily temperatures (maximum and minimum) and evaporation rates during different weeks in *rabi* 2000-01 and 2001-02 seasons

crop season, maximum and minimum temperatures were 1-2°C higher during early vegetative and late flowering period till grain filling stage as compared to the second season. Pan evaporation values were also higher (about 1 to 2 mm/day) during first crop season at seed filling and maturity periods However during flowering and pod initiation stages the difference was not so appreciable. The influence of weather on crop growth stages is prominent from the fact that the duration of all three *Brassica* cultivars was shortened with delay in sowings. Among different phenological stages, the grain filling stage was found to be the most responsive to temperature fluctuations. The grain filling stage of first sown crop continued for a longer period as compared to other two sowings because of low temperatures prevailing at that period in both the seasons.

Leaf area index

In the first crop season (*rabi*, 2000-01) the peak leaf area index (LAI) was lower for all the cultivars and sowing dates as compared to the second season, which was relatively warmer (1 to 2°C) during vegetative phase of crop growth. In all the three cultivars maximum leaf area index was attained in the first sowing, followed by second and third sowing. The peak LAI was the highest in cultivar Pusa Jaikisan (6.5 to 6.7) followed by Varuna (4.6 to 6.6) and Agrani (4.4 to 6.4) in three respective sowings. Leaf area index steadily increased and reached a maximum around pod formation stage (50 % flower to 90 % podding stage), irrespective of differences in weather conditions prevailed in the two seasons. Later, the leaf area index declined rapidly. Senescence and abscission coincided with onset of flowering and completed well before maturity. Growing demands for remobilizing nitrogen by the fast growing reproductive organs seemed to be one of the causes for leaf senescence as in rape plants (Allen *et. al.*, 1971).

Above ground biomass production

The biomass accumulation was lower in the first season which may be attributable to the effect of relatively higher temperature by 1-2°C during the active growth period. In all the cultivars peak biomass production was observed in the first sowing, followed by second and third sowings as can be expected. The later sowings were subjected to higher mean daily temperatures (6 to 11°C) and relatively higher evaporative demand (2 to 3 mm/day) than those of first sowing during post flowering period till maturity. It is also observed that the highest amount of biomass accumulated was in cultivar Pusa Jaikisan (1231 to 1579 g m^{-2}) followed by Varuna (1219 to 1326 g m^{-2}) and Agrani (875 to 1392 g m^{-2}). Our studies are in conformity with Singh *et al.* (2002) who reported that a sudden drop in temperature (from 25.6 to 15.4°C) particularly during the grand growth period followed by a sharp rise (from 32.4 to 41.5°C) in it at crop maturity under delayed sowing led to reduced biomass accumulation and its allocation to various plant parts.

Crop growth rate (CGR)

The crop growth rates (CGR) or dry matter accumulation per unit area over time steadily increased till 80-90 days after sowing (DAS). In the cultivar Pusa Jaikisan, the highest CGR (29.2 g m^{-2} day^{-1}) was observed in the first sowing at 80 to 90 DAS followed by second (26.8 g m^{-2} day^{-1}) and third sowing (22.1 g m^{-2} day^{-1}). In the second season also the peak CGR decreased as the sowing was delayed, the values being 35, 28.1 and 21.2 g m^{-2} day^{-1} in the first, second and third sowings, respectively (Table 1). Due to profuse growth habits, the cultivar Pusa Jaikisan recorded the highest growth rate in all the sowings. Same trend was observed in other two cultivars though the actual values were lower. For Pusa Bold, Kar (1996) found that the maximum CGR varied from 29.4 to 23.3 g m^{-2} day^{-1} and from 34.8 to 25.8 g m^{-2} day^{-1} during *rabi* 1993-94 and 1994-95 seasons, respectively as the sowing was delayed from October 15 to November 16.

Pod growth rate

Like CGR the pod growth rate was also found to be maximum in first sowing of Pusa Jaikisan (12.5 to 22 g m^{-2} day^{-1}) as compared to third sowing (11.2 to 13.6 g m^{-2} day^{-1}). In case of the cultivar Varuna, the corresponding values were 12.0 to 17.6 g m^{-2} day^{-1} and 9.6 to 11g m^{-2} day^{-1} and in Agrani these were 10.7 to 16.8 g m^{-2} day^{-1} and 7.4 to 10.4 g m^{-2} day^{-1}, respectively. In case of the third sowing, during the pod growth stage (from 60 days onwards) in the first season the minimum temperatures were found to be below 5°C almost continuously for 12 days while in the second season the temperatures were lower for 14 days. Since for *Brassica* the metabolic activity ceased to function below 5°C (Morrison *et al.*, 1990), these low temperatures prevailed might have resulted in lower pod growth rate in both the seasons in the third sowing. The mean pod growth rates (mean of three plantings of each variety in a season) were computed and are shown in the Fig. 2. It is interesting to note that the cultivar Pusa Jaikisan has responded favourably for the low temperature (during the second season) followed by Agrani and Varuna. In the relatively longer duration varieties Pusa Jaikisan and Varuna, in the two seasons the maximum pod growth rate occurred between 90-100 DAS. But in case of Agrani the higher temperatures during pod growth period was clearly seen. In the second season when temperatures are relatively lower, the pod growth rate continue to increase up to 90-100 DAS and decreased towards next ten-day period. While in the first season when temperatures were relatively higher pod growth rates have drastically reduced from 9.4 to 6.5 and 6.5 to 3.2 g m^{-2} day^{-1} in the 80-90, 90-100 and 100-110 DAS, respectively which reduced the mean grain yield from 19.1 q ha^{-1} (season 2) to 15.6 q ha^{-1} (season 1).

Table 1. Mean peak crop growth rate (g m^{-2} day^{-1}), pod growth rate (g m^{-2} day^{-1}) and yield (q ha^{-1}) during two rabi seasons (2000-01 and 2001-02) as influenced by sowing dates

Cultivars	First sowing		Second sowing		Third sowing	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Peak CGR						
Agrani	20.8	27.2	16.9	24.3	15.4	22.5
Pusa Jaikisan	29.2	35.0	26.8	28.1	22.1	21.2
Varuna	24.5	28.2	19.0	26.6	16.1	18.9
Peak pod growth rate						
Agrani	10.7	16.8	10.0	12.9	7.4	10.4
Pusa Jaikisan	12.5	22.0	12.4	21.3	11.2	13.9
Varuna	12.0	17.6	10.9	12.2	9.6	11.0
Grain yield						
Agrani	18.0	21.0	17.0	20.0	11.9	16.4
Pusa Jaikisan	18.8	24.5	17.7	21.0	14.0	18.2
Varuna	18.3	22.5	17.2	21.0	12.9	17.9

C.D. value for peak crop growth rate (cultivars and sowings) = 3.10 (2000-01) and 4.36 (2001-02)
C.D. value for peak pod growth rate (cultivars and sowings) = 4.64 (2000-01) and 4.90 (2001-02)
C.D. value for grain yield (cultivars and sowings) = 2.51(2000-01) and 1.89 (2001-02)

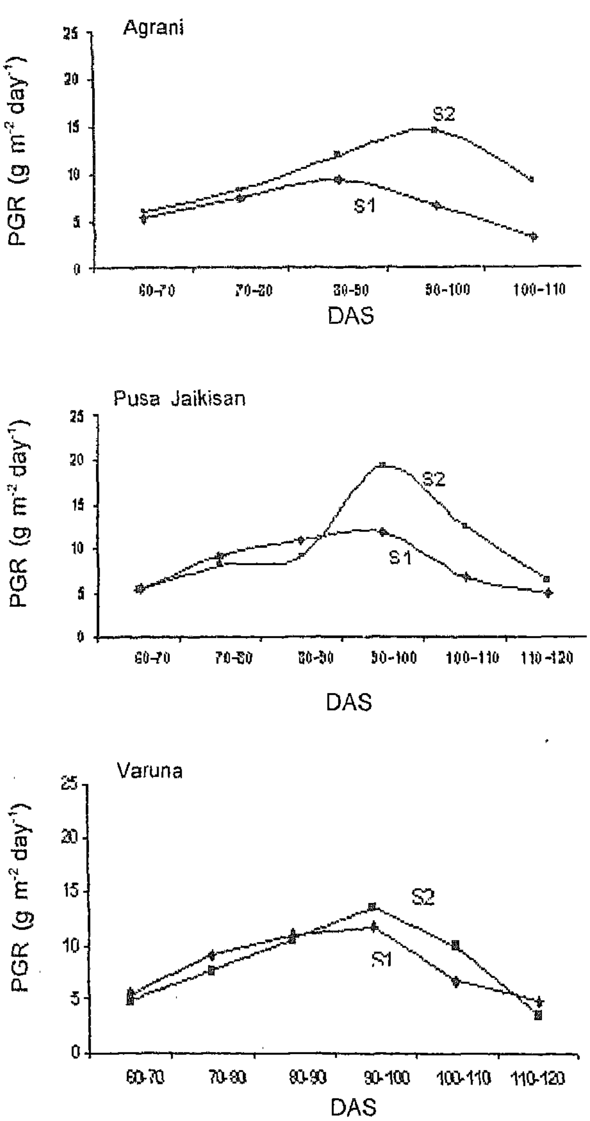

Fig. 2. Variation in pod growth rate (PGR) of three Brassica cultivars (pooled value for three plantings) during *rabi* 2000-01 (S1) and 2001-02 (S2).

Thus it can be inferred that the early maturing variety Agrani is susceptible for minor variation in the temperature as compared to longer duration varieties Pusa Jaikisan and Varuna.

Grain yield

The first crop season recorded the highest grain yield of 18.8 q ha^{-1} in the first sowing of Pusa Jaikisan and the lowest of 11.9 q ha^{-1} in the third sowing of Agrani (Table 1). In the cultivar Agrani, the yield reductions in second and third sowings were 5.5 and 33.8 per cent respectively over the first sowing of first season, where as in Pusa Jaikisan the yield reductions were 5.8 and 25.5 per cent and in Varuna the respective reductions were 6 and 29.5 per cent in two late sown crops. The same trend was observed in the second season. Yield due to late sowing was significantly affected ($P < 0.05$) in all the three cultivars.

Thus it can be seen from biomass partitioning and pod growth rate that the prevailing lower temperature (below 5°C) during pod growth stage in the third sown crops has resulted in relatively less pod growth rate as compared to the other two sowings.

Conclusions

Thus the present study clearly showed that in *Brassica* the lower temperatures of 2-3°C during entire growth period could reduce the leaf area index, crop growth rates, pod growth rates and seed yields by approximately 10 -20 per cent.

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