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Effect of Sowing Date and Irrigation on Leaf Area Index and Biomass of Mustard Cultivars

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ABSTRACT: Indian mustard (*Brassica juncea* L.) is a long day plant, which requires fairly cool climatic condition during growth and development. A field experiment was conducted during the *rabi* season of 2020-21 at IARI farm with three mustard cultivars, *viz.*, Pusa Vijay, Pusa Mustard-21 and Pusa Bold in Split plot design to study the influence of date of sowing and irrigation levels on Leaf Area Index (LAI) and biomass accumulation of mustard cultivars. Proper handling of plant canopy analyser for LAI reading and proper care and management for biomass sampling and drying were some of the challenges needed to account during the experiment. Timely sown crop has higher crop growth rate mainly due to high leaf area index which accumulated dry matter at a faster rate per unit leaf area per unit time and subsequently it decreased with delay in sowing. At the early vegetative phase, total dry matter (TDM) increased slowly but with the advancement of growth period there was rapid increase of TDM. LAI in cultivars attained peak values around 5.1 to 5.3 and 3.2 to 3.8 for Ist sowing (D_1) and 2nd sowing (D_2), respectively. The effect of irrigation level were found a little after second irrigation. Above ground Biomass accumulation of all the cultivars followed S shaped curve irrespective of sowing dates and irrigation levels. Initially there was a slow growth phase up to rosette formation followed by rapid growth phase up to seed filling stage and then reached a plateau. However rate of growth and final biomass accumulation differ due to cultivars, sowing dates and irrigation levels. Biomass accumulation also reduced significantly from 11.67 t ha^{-1} to 7.48 t ha^{-1} due to delay in sowing. Biomass reduced from 9.94 t ha^{-1} to 9.21 t ha^{-1} due to reduction in irrigation frequency.

Keywords: Indian Mustard, LAI, TDM, Date of sowing, Pusa Bold

INTRODUCTION

Mustard plants are thin herbaceous with yellow flowers. The leaves of the plant are toothed, lobed, and occasionally have the larger terminal lobes. Mustard is an oilseed crop and its seed contains 33 to 40 per cent oil. Indian mustard is grown in *rabi* season (October to April) in North-West plains of India and subjected to various types of abiotic and biotic stresses. Indian mustard (*Brassica juncea* L.) is a long day plant, which requires fairly cool climatic condition during growth and development for obtaining biomass and better seed yield. Time of sowing is very important for mustard production (Mondal and Islam, 1993; Mondal *et al.*, 1999). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield and different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey *et al.*, 1981). Water serves as a medium for nutrient absorption by the crop; most of the herbaceous plant parts constitute about 80-90% of water and almost every plant process is affected directly/indirectly by the water supply (Balasubramaniyan and Palaniappan, 2001). Optimum time of sowing and irrigation is necessary for proper growth and development of mustard crop. Leaf area index (LAI) is a dimensionless quantity that characterizes plant canopies. Leaf area index is an important parameter for the crop growth studies since it is useful in interpreting the capacity of a crop for producing dry matter in terms of the utilization of intercepted radiation through photosynthesis. Timely sown crop has higher crop growth rate mainly due to high leaf area index which accumulated dry matter at a faster rate per unit leaf area per unit time and subsequently its decrease with delay in sowing (Thurling, 1974). LAI at the time of flowering was found to be positively correlated with biomass in winter grown mustard and rapeseed (Clarke and Simpson, 1978; Kler 1992). LAI of *Brassica* cultivars was lower in a season with higher temperatures (2 to 3°C) during vegetative and grain filling stages as compared to the season with relatively lower temperatures in the same period (Kar and Chakravarty, 1999). Biomass production of the plant is the process of formation of carbohydrates, the products of photosynthesis from atmospheric carbon dioxide, water and small quantity of inorganic substance absorbed by roots from the soil. At the early vegetative phases total dry matter (TDM) increased slowly but with the advancement of growth period increased rapidly and rapid increase of TDM was due to green stem and pod photosynthesis at the later stages (Scott *et al*. 1973). Very few work were found on on LAI and biomass cumulative. Therefore, the present investigation was under taken to find out the effect of dates of sowing and different levels of irrigation on LAI and biomass of mustard cultivars.

MATERIALS AND METHOD

A field experiment was conducted on three different cultivars of mustard during the *rabi* season of 2020-21 (October to March). The experiment was done at the research farm of Division of Agricultural Physics of ICAR-Indian Agricultural Research Institute, New Delhi. The soils of the area are non-calcareous, alkaline in reaction and are sandy loam in texture. The three cultivars were grown in the MB-4C field for the experiment and they were Pusa Vijay, Pusa Mustard-21 and Pusa Bold.

The two dates of sowing were chosen for the experiment. The first and second dates of sowing were 30th October, 2020 and 18th November, 2020 respectively. The first date of sowing was considered as normal sowing. The second date of sowing was considered as late sowing. The design of experiment was split plot design. The three treatments were:- Main plot =Sowing dates (2), Sub plot =Irrigations (2) and Sub sub plot = Cultivars (3). The 1st irrigation was given to all the treatments at rosette (pre-flowering) stage. During seed filling stage second irrigation was given for I2 treatments for both normal (D1) and late sown (D2) crop. This second irrigation was not given to I1 treatments. Plant Canopy Analyser (LI-COR, USA) were used to measure LAI of plants. The readings were taken at late evening (3:30pm - 4:30 pm in IST) as the technique is based on measurement of diffused radiation. Plant Biomass was estimated through destructive sampling method. Plant samples that were collected from the field were kept in paper envelopes and fresh weight were taken. Sample collecting envelopes containing sample were oven dried at 65°C for 48 hours and sometimes more, until a constant weight was achieved and after that again dry weight were taken.

RESULTS AND DISCUSSION

Data of leaf area index (LAI) of three mustard Cultivars shown on two different date and grown with two irrigation level for *rabi* season of 2020-21 as shown in (Fig. 1, 2 and 3). In general, initially LAI started increasing at very slow rate, and then rapid increase took place from rosette stage and reached a maximum during pod formation stage and later decline sharply at seed filling stage.

LAI in cultivar Pusa Vijay attained peak values 5.3 and 3.4 for D_1 and D_2 sowings, respectively. The peak values were attained around 80-90 days after sowing (DAS). LAI in cultivar Pusa Mustard-21 attained peak values 5.2 and 3.8 for D_1 and D_2 sowings, respectively. The peak values were attained around 80-90 days after sowing (DAS). LAI in cultivar Pusa Bold attained peak values 5.1 and 3.2 for D_1 and D_2 sowings, respectively. The peak values were attained around 80-90 days after sowing (DAS). Maximum LAI was observed in 30th October sown crop, followed by 18th November sown crops. Time to attain the peak values was also delayed for delay in sowing.

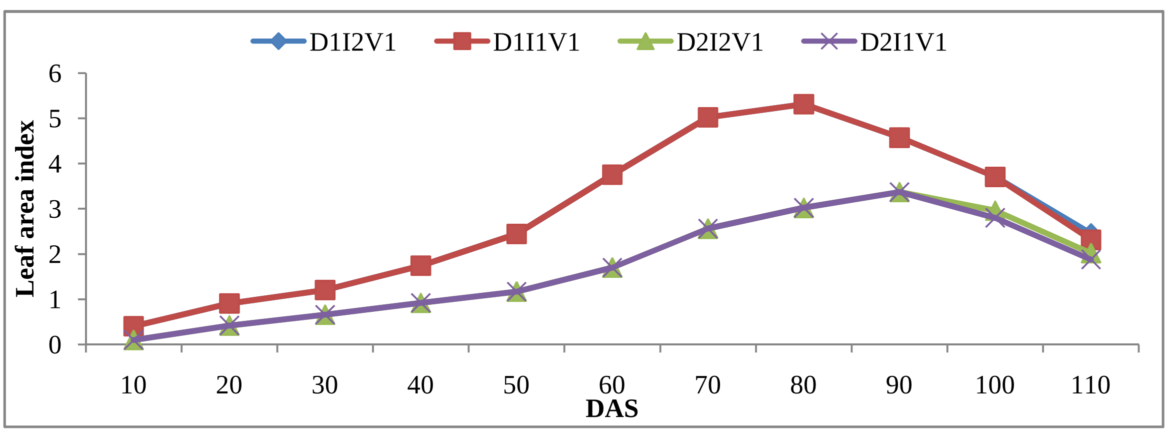

Fig. 1. LAI of Pusa Vijay for two dates of sowing at IARI farm during *rabi* season, 2020-21.

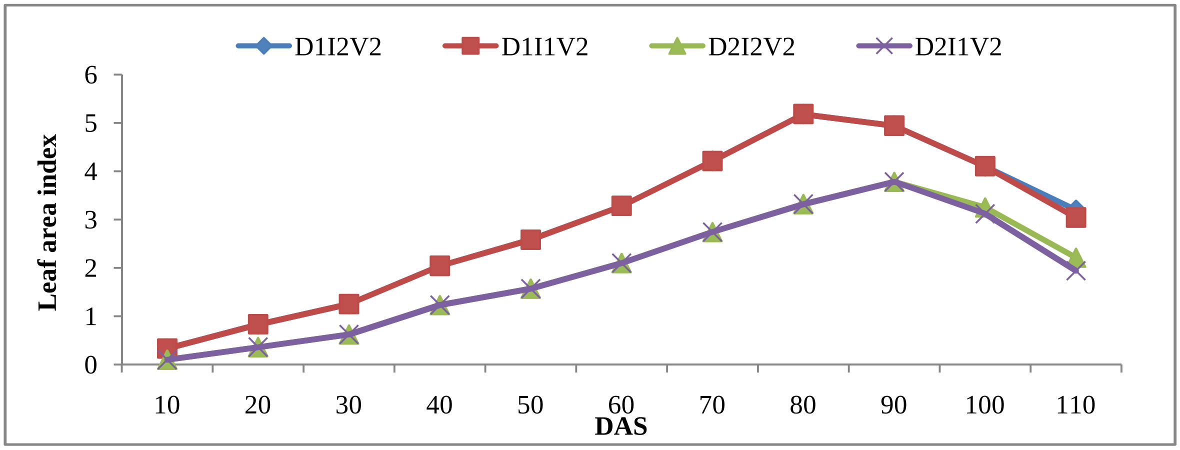

Fig. 2. LAI of Pusa Mustard-21 in two dates of sowing at IARI farm during *rabi* season, 2020-21.

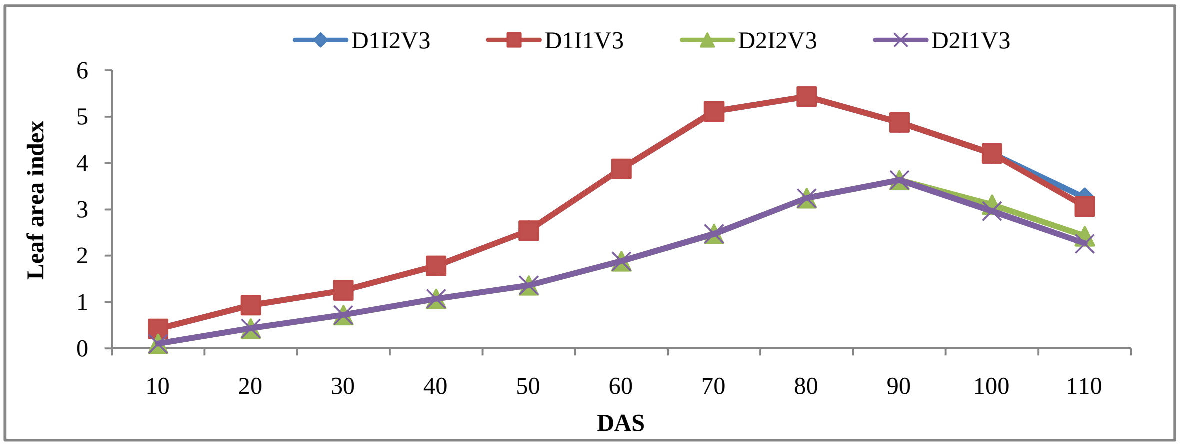

Fig. 3. LAI of Pusa Bold in two dates of sowing at IARI farm during *rabi* season, 2020-21.

The cultivars did not differ for peak values of LAI and time to attain these peak values but these differ from first (normal) to second (late sowing). The effect of irrigation levels were found a little after second irrigation. At that time majority leaves were senescence and it represent the pod area index mainly in case of first sown crop. In case of second sown crop, second irrigation was given at 87 DAS. At that time green leaves were present mostly along with the pods, therefore change in LAI for two irrigation levels were conspicuous after 90 DAS.

The peak value of leaf area index (LAI) reduced significantly from 5.2 to 3.4 due to delay in sowings. This might not be related to terminal heat stress but the temperature and radiation condition of vegetative stage. The cooler temperature during the vegetative stage in late sown crop probably reduced the LAI. The reduction in peak value of LAI due to delay sowing, may be due to low temperature experienced by vegetative stage in late sown crop (Nishad, 2017). The attainment of peak LAI was also delayed due to delay in sowing. This might be due to slower growing degree days (GDD) accumulation in vegetative period. The difference in peak LAI values and time of attaining those were significant across the sowing dates as well as cultivars. The LAI of Pusa Vijay sown on 30th October was found to be superior to other treatments.

Above ground Biomass accumulation

Above ground Biomass accumulation of all the cultivars followed S shaped curve irrespective of sowing dates and irrigation levels. Initially there was a slow growth phase up to rosette formation followed by rapid growth phase up to seed filling stage and then reached a plateau. However rate of growth and final biomass accumulation differ due to cultivars, sowing dates and irrigation levels. Fig. 4 to 6 depicted how the biomass accumulation of three cultivars took place in different conditions. The growth of first sown (D1) crop was faster than the second sown crop (D2) and that created difference in final biomass in larger extent. The effect of irrigation levels was prominent 110 DAS in first sown crop and 90 DAS in second sown crop.

Pusa Vijay. In D1 and D2 sowings, the highest biomass was recorded 11.63 t/ha and 7.47 t/ha, respectively for the one irrigation and for the two irrigation treatment the biomass recorded was 12.70 t/ha and 8.28 t/ha in D1 and D2 sowings respectively. Due to a delay in seeding, the final biomass production reduced by 34% to 35% (Table 1) in different dates of sowing and it was reduced by 9 % as irrigation was reduced from two irrigations to one irrigation.

Pusa Mustard-21. In D1 and D2 sowings, the highest biomass was recorded 11.36t/ha and 6.97 t/ha, respectively for the one irrigation and for the two irrigation treatment the biomass recorded was 12.31 t/ha and 7.63 t/ha in D1 and D2 sowings. Due to a delay in seeding, the final biomass production reduced by 38% (Table 1) in different dates of sowing.

Pusa Bold. In D1 and D2 sowings, the highest biomass was recorded 10.78t/ha and 6.82 t/ha, respectively for the one irrigation treatment and for the two irrigation treatment the biomass recorded was 10.98 t/ha and 7.78 t/ha. Due to a delay in sowing, the final biomass production reduced by 29% to 36% (Table 1). I_1 treatment have shown a reduction in biomass production in the range of 2% to 8%. The higher reduction of 8% was observed in Pusa Vijay and the lowest reduction of 2% was observed in Pusa Bold.

Table 1: Biomass of mustard cultivars under different irrigation levels in two different date of sowings.

Biomass(t/ha)	I1V1	I2V1	I1V2	I2V2	I1V3	I2V3
D1	11.63	12.70	11.36	12.31	10.78	10.98
D2	7.47	8.28	6.97	7.63	6.82	7.78
% Deviation	35.71	34.84	38.68	38.03	36.71	29.12

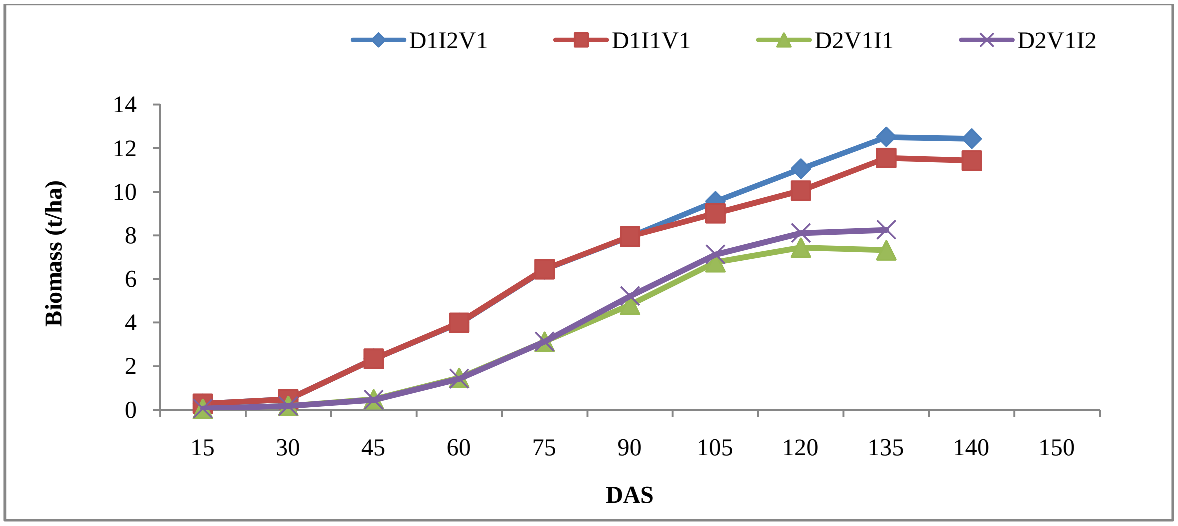

Fig. 4. Biomass accumulation of Pusa Vijay in two dates of sowing at IARI farm during *rabi* season, 2020-21.

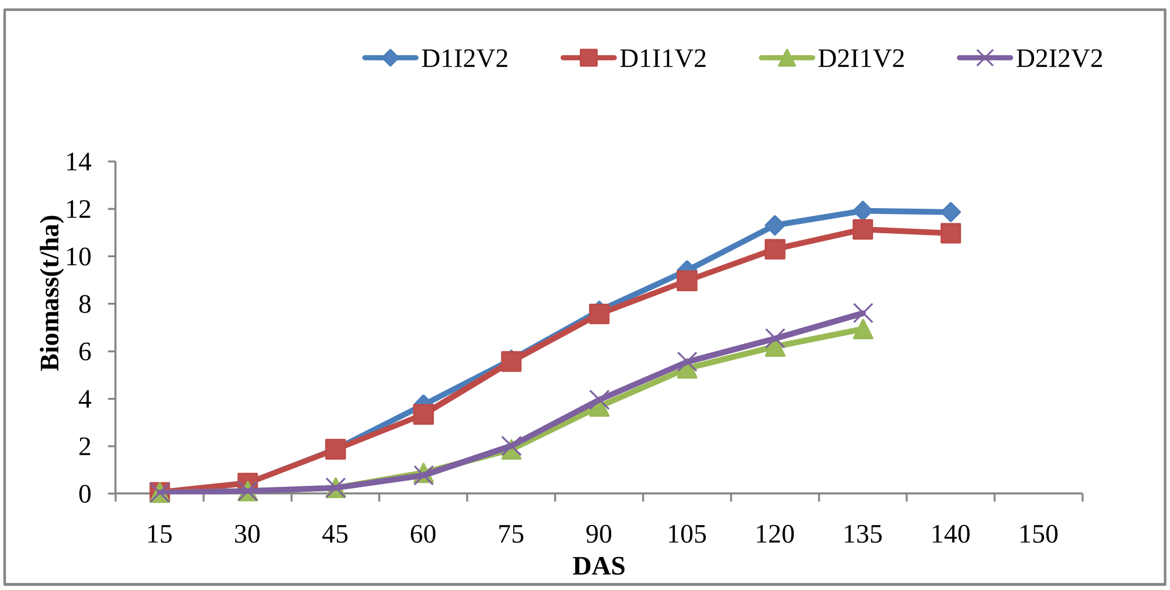

Fig. 5. Biomass accumulation of Pusa Mustard-21 in two dates of sowing at IARI farm during *rabi* season, 2020-21.

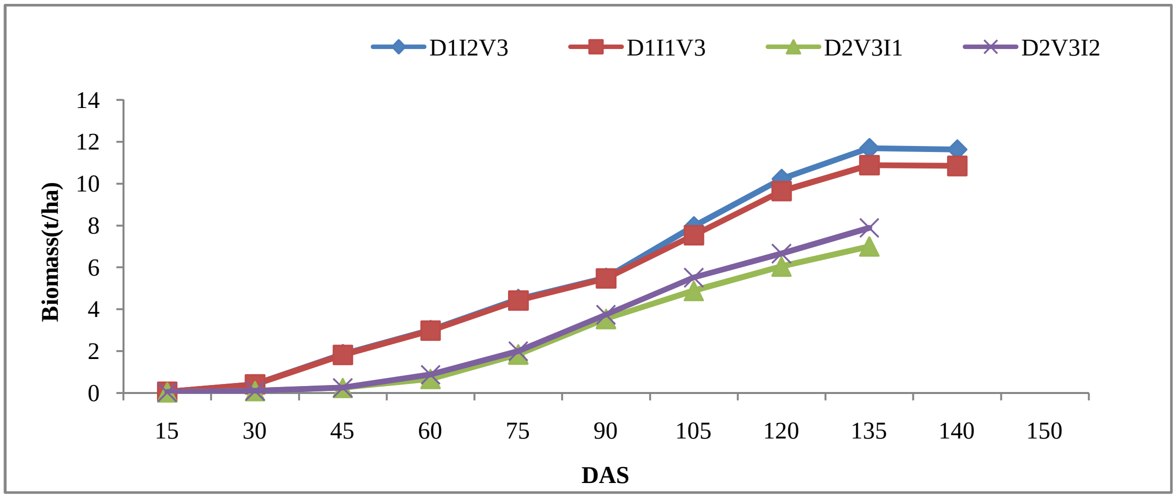

Fig. 6. Biomass accumulation of Pusa Bold in two dates of sowing at IARI farm during *rabi* season, 2020-21.

Table 2: Final Biomass of mustard cultivars under different irrigation levels in two different dates of sowings.

	Biomass (t/ha)
D1	11.67^{A}
D2	7.48^{B}
LSD (0.05)	0.66
I1	9.21^{B}
I2	9.94^{A}
LSD (0.05)	0.26
V1	10.03^{A}
V2	9.58^{B}
V3	9.12^{C}
LSD (0.05)	0.17

Biomass accumulation also reduced significantly from 11.67 t ha^{-1} to 7.48 t ha^{-1} due to delay in sowings (Table 2). Biomass production was reduced drastically due to delay in sowing (Roy and Chakravarty, 2007). Duration of reproductive stage reduced in late sowing and the higher temperature during that stage lead to higher respiration. So, net photosynthesis is reduced. Mainly seed filling during reproductive stage was affected due to high temperature. Inhibition to import photosynthates in high temperature during this stage reduced sink strength (Subramanyam and Rathore, 1994).

Significant decrease in final biomass was observed when one irrigation was withdrawn at seed filling stage. Biomass reduced from 9.94 t ha^{-1} to 9.21 t ha^{-1} (Table 2) due to reduction in irrigation frequency. Probably moisture stress resulted in reduced biomass. As it is generally accepted that water shortage is a major yield determining factor (Day and Legg, 1983), the effect of water availability has been the subject of several studies. Attention has been paid to the identification of growth stages especially sensitive to lack of water. Irrigation has been shown to increase yield of the plants (Stoker and Carter, 1984; Wright *et al.*, 1988). Response varies with the season, but there appears to be no benefit from applying more than two irrigations (Stoker and Cater, 1984). Rapeseed responds largely to water supply at the start of flowering (Davidson, 1976). According to Saran and Giri (1986), one irrigation at 45 to 90 days or two irrigations at 30 and 90 days (at pre-flowering and 50% of pod formation stages) significantly increase yield and yield components of mustard. Irrigation at 30 days after sowing is necessary for higher branching, which influenced the number of pods/plant (Bajpai and Singh, 1981). Total production of dry matter of *B. juncea* was significantly increased by water supply. A similar response to irrigation was reported by Natharson *et al.* (1984), Khan and Agarwal (1988); Garside *et al.*, (1992). A decrease in dry matter production by water stress was due to a decrease in total leaf area per plant and a decrease in number of cell per unit leaf area (Delgado *et al.*, 1992).

CONCLUSION

The time of sowing and different level of irrigation affect the LAI and Biomass accumulation of the crop. LAI increased slowly, then rapidly from the rosette stage onwards, attaining peak during the pod formation stage and then sharply decline during the seed filling stage. The peak value of leaf area index (LAI) reduced significantly due to delay in sowings. Biomass accumulation also reduced significantly due to delay in sowings and when one irrigation was withdrawn at the seed filling stage, a significant reduction in final biomass was also found due to different irrigation levels.

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