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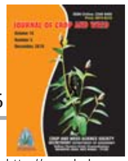

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Effect of foliar spray on phenology and yield of Lentil sown on different dates

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ABSTRACT

A field experiment was conducted at BCKV during rabi, 2018-19 to study the effect of Zn, Fe and B foliar spray on phenology, growth and yield of popular lentil variety; Moitiri(WBL 77) under different sowing condition (1st week of November and 1st week of December). Delay in sowing though reduce the yield in second date of sowing, a foliar spray combination of B+Fe @0.5% recorded almost double the yield (1431 kg ha^{-1}) than control (748 kg ha^{-1}). Delay in sowing of crop from November 1st week to December 1st week reduced the duration by 11.67 days (113.41 days vs 101.74 days). Mean days of lentil from sowing to emergence, flower initiation, pod initiation and maturity for first date of sowing were 8.0, 47.81, 16.22 and 41.52. The crop completed these respective stages in 10.96, 38.39, 20.63 and 31.26 days in second date of sowing, respectively. The treatment with B+Fe+ Zn @ 0.5% through recorded highest plant height (49.22), highest nodule number (30.83) and no. of flowers (323.17), the highest yield was recorded in B+Fe @0.5% (1431.11 kg ha^{-1}). This is mainly because of the completion among the flowers because of more number of flowers resulting in more flower drop and less number of pods.

Keywords: Growth attributes, lentil, phenology, seed yield

Rising temperatures are putting the future global food supply as well as nutritional security at significant risk. More than global temperature rise, local temperature increase is of much concern as it can drastically affect the crop growth and yield. The prevalence of high temperature is expected to increase in the near future (IPCC, 2014). The sensitivity of crop plants to heat stress will increase by the end of this century with the escalating high temperature variability (Jha *et al.*,2014). Elevated temperatures causes various morpho-anatomical, physiological, reproductive and biochemical changes in plants, which can affect plant growth and development and ultimately lead to a reduction in economic yield (Beta and Gerat, 2013). The effects of heat stress, mainly at the time of the reproductive stage and seed development of plants, are gaining attention as they are a serious threat to the productivity of leguminous crops by reducing pollen viability, fertilization and pod set (Gaur *et al.*, 2015).

Lentil, a cool season, nutritious food legume is highly sensitive to high temperature and moisture stress, particularly during reproductive growth, which drastically reduce seed yield (Sita *et al.*, 2017). Legume is a very import crop in West Bengal. As Lentil is grown after the *monsoon* crop, in most of the cases the sowing of the crop gets delayed either due to long duration of *monsoon* crop or delay in the preparation of the field. In addition to this, chilling periods are becoming shorter and heat periods are becoming longer in northern parts of India, resulting in the exposure of cool-season crops to heat stress. Long term trend analysis data of this region shows that the crop would face adverse effect of heat stress when sown late. Foliar application of micronutrients helps in the rapid translocation when compared to soil application which is very pertinent in mitigating stress in plants. Hence we may expect that foliar spraying of Fe, Zn and B either individually or in combination during reproductive stage will help in mitigating heat and moisture stress in lentil sown in late conditions.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season (November – March) of 2018-19 at the District Seed Farm, AB block, Kalyani, Bidhan Chandra KrishiViswavidyalaya, (Latitude 22º58´ N and Longitude 88º32´ E), West Bengal, India. The study site is flat and is located at an altitude of 9.75 m above mean sea level (AMSL).The experiment was laid in a split-plot design with two sowing dates (Novermber 1st week and December 1st week) in main plots and 9 foliar spray (S_1: No spray, S_2: Foliar spray of tap water, S_3: Foliar spray of Zn @ 0.5 % (ZnSO4.7H2O), S_4: Foliar Spray of Fe@ 0.5 % (FeSO4.7H2O), S_5: Foliar spray of B @ 0.2 % (Borax 10.5 %), S_6: Foliar spray of Zn@0.5% +B@0.2%, S_7: Foliar spray of Zn@0.5% +Fe@0.5%,

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S_8: Foliar spray of B@0.2% +Fe@0.5% and S_9: Foliar spray of Zn@0.5% +Fe@0.5% +B@0.2%) in sub-plots replicated thrice. The seeds were sown at 30 cm spacing in experimental plot of (5 x 4 cm) as per sowing time of various main plot treatments.The standard crop management practices like uniform fertilizer dose of 20:40:40 kg ha^{-1} of N: P_2O_5 and K_2O, one hand weeding at 25-30 days after sowing(DAS) were given. No irrigation was provided because lentil was mainly grown on residual soil moisture along with little precipitation during *rabi* season and we had to see the crop stress during the growth.

The phenophases (*viz*. emergence, flowerinitiation, pod initiation and maturity) of lentil varieties sown at different dates were noted by regular field inspection method. The number of nodules plant counted from the root samples and total dry matter (g m^2) were noted at 45, 60, 75 and 90 DAS. The plant height, yield components, seed and stover yield of lentil were recorded at crop maturity. The data collected as described earlier in the investigation were subjected to the analysis of variance method suitable for split plot design by Statistical software R

RESULTS AND DISCUSSION

Phenology

The duration of lentil crop was successively reduced with delay in sowing from November first week to December first week (Table 1). On an average Lentil sown on November first week took 113.41 days from sowing to maturity. However, the crop sown on December first week finished its life cycle in 101.74 days. A reduction of 11.67 days was observed in the study. Singh et al. (2005) reported similar reduction in time to 50% flowering and maturity for delay in sowing of lentil (cv. LG 308) from 10 November to 10 December at Gurdaspur, Punjab. Sen et al. (2016) also reported similar trend in a study with four lentil varieties (HUL 57, Moitree, KLS 218 and Ranjan) sown on three different dates in West Bengal. Though the variations among the stages are not uniform, germination – flowering (G-F) and pod initiation to maturity (PI – M) noted in the study probably influenced the life cycle of lentil crop as a whole.The emergence of seedlings of lentil was relatively faster (8.00 days) in November first week sownplots compared to later sown dates *viz*.,December first week (10.96 days), which might be due to better residual soil moisture during post rainy period after sowing.

Mean days for the crop sown on November first week from sowing to emergence (E), Germination to flowering initiation (FI), Flowering to pod initiation (PI), and maturity (M) were 8, 55.81, 72.03 and 113.41. On other hand the second date of sowing finished the respective stages of growth in 10.96, 49.89, 70.52 and 101.74 days respectively. Though changes in life cycle was not expected, foliar spray of B+Fe @0.5% and B+Zn+Fe@0.5% resulted in a increase of two day when compared with no spray to attain maturity. This may be attributed to the fact that, as an indeterminate crop, the foliar spray might have boosted the flower production resulting in a longer span.

Plant height and dry matter accumulation

Delay in sowing from November first week to December first week has reduced the plant height by 6.02 cm (50.43 vs. 44.41 cm) (Table 2). The foliar spray with B@0.5 % (51.28cm) resulted in highest plant height (49.22 cm) followed by B+Fe +Zn @0.5% (49.22 cm). Besides, the height varied between 44.20 cm and 51.28 cm.

Dry matter (DM) accumulation showed an upward trend with the advancement of crop age upto 90 DAS. Sowing time had a larger influence during the later stage of the crop (90 DAS). The initial stages differences were insignificant. This may be probably due to rapid development of pods and seeds within shorter period in the second date of sowing. Lentil sown on November first week produced the highest dry matter at 90 DAS (117.66g m^{-2}). The results were in accordance with the findings of Gill *et al*. (2012) in Punjab. Though the growth of the plants is its varietal character, the difference in dry matter accumulation among different treatments is due to the role each nutrient play in growth and development. The treatment which received the foliar spray of B+Fe@0.5% recorded highest biomass (122.72g m^{-2}). It recorded approximately 12 % increase in dry matter accumulation when compared with control (no spray)

Nodulation

The nodulation increased progressively from 45 to 60 DAS (Table 2). Though the number of nodules was more in first date of sowing the results were not found significant. Singh (1986) has also reported a decreasing trend in number of nodules with delay in sowing from November to December in West Bengal. However, the effect of foliar spray was highly visible. Foliar spray with B+Zn+Fe@0.5 % recorded highest no of nodule (30.83) followed by foliar spray of B+Fe@0.5% (28.50) when compared with control (23.50).

Number of flowers

The second date of sowing had a drastic reduction in number of flowers (245.85) when compared to first date of sowing (308.78). As the winter is very mild in this region, delay in sowing leads the crop to experience

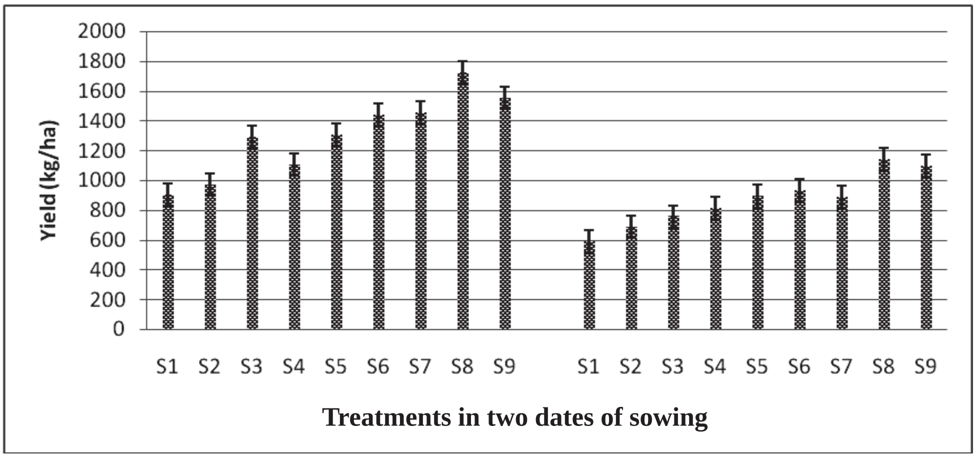

Fig. 1: Interaction effect of sowing time and foliar spray on seed yield of lentil

Table 1: Effect of date of sowing and foliar spray on phenological development of lentil

Treatment	Sowing to emergence	Germination to flowering	Flowering to pod initiation	Pod initiation to maturity	Life cycle Sowing-maturity
D_1	8.00	47.81	16.22	41.52	113.41
D_2	10.96	38.93	20.63	31.26	101.74
S.Em(±)	**0.05**	**0.08**	**0.10**	**0.09**	**0.05**
LSD (0.05)	**0.32**	**0.48**	**0.64**	**0.57**	**0.28**
S_1	9.50	42.83	18.83	35.33	106.67
S_2	9.33	43.50	18.67	35.50	107.33
S_3	9.33	43.17	18.83	36.00	107.33
S_4	9.50	43.17	18.17	36.33	106.83
S_5	9.67	43.50	18.33	36.50	108.00
S_6	9.67	43.50	18.33	36.67	107.67
S_7	9.33	43.50	18.50	36.83	107.67
S_8	9.50	43.67	18.17	37.17	108.67
S_9	9.50	43.50	18.00	37.17	108.00
SEm(±)	**0.13**	**0.29**	**0.25**	**0.24**	**0.43**
LSD(0.05)	**NS**	**NS**	**NS**	**0.70**	**NS**

S_1: No spray, S_2: Foliar spray of tap water, S_3: Foliar spray of Zn @ 0.5 % (ZnSO4.7H2O), S_4: Foliar Spray of Fe@ 0.5 % (FeSO4.7H2O), S_5: Foliar spray of B @ 0.2 % (Borax 10.5 %), S_6: Foliar spray of Zn@0.5% +B@0.2% , S_7: Foliar spray of Zn@0.5% +Fe@0.5%, S_8: Foliar spray of B@0.2% +Fe@0.5% and S_9: Foliar spray of Zn@0.5% +Fe@0.5% +B@0.2%

heat and drought stress thus resulting in flower drop, pollen abortion and thus reduction in yield. Temperatures above 32/20 °C (max./min.) at the time of flowering and pod filling in lentil can drastically reduce seed yield and quality (Delahunty *et al.*, 2015; Bourgault *et al.*, 2018). During the later phase, the crop has experience a temperature beyond this limit. Among the foliar treatments, spraying with B+Zn+Fe@0.5 % recorded highest no of flowers followed by B+Fe@0.5 % (297.33). All these three micronutrient used in the spray has a positive role in reproductive growth. Zn deficiency has also been shown to change stigmatic size, morphology, and exudations, inhibiting pollen-stigma interaction (Pandey *et al.*, 2006).The role of boron for pistil development and pollination to fertilization has also reported by many researchers. Similarly Iron plays a significant role in various physiological and biochemical pathways in plants. Thus this combination of nutrient and a boost up spray during flowering and pod development might have resulted in this higher number of flowers.

Table 2: Effect of sowing time and foliar spray on nodulation, plant height, no of flowers and dry matter accumulation of lentil

Treatment	Nodules		Plant height		No. of flowers	Dry matter	
	45DAS	60DAS	75DAS	90DAS	Throughout	75DAS	95DAS
D_1	10.89	26.44	36.12	50.43	308.78	67.75	117.66
D_2	12.37	25.04	32.52	44.41	254.85	70.18	104.57
SEm(±)	**1.01**	**0.44**	**0.07**	**0.55**	**2.39**	0.25	1.14
LSD(0.05)	**NS**	**NS**	**0.46**	**3.38**	**14.55**	1.52	6.91
S_1	11.83	23.50	30.03	44.20	239.50	66.55	105.62
S_2	12.00	23.17	32.52	46.57	252.67	65.23	108.30
S_3	11.83	22.67	33.42	46.90	281.00	69.62	107.82
S_4	12.00	24.50	34.10	47.40	281.33	71.25	110.48
S_5	11.33	25.67	34.88	51.28	294.17	70.18	111.60
S_6	12.17	26.33	36.22	49.45	290.67	71.43	113.87
S_7	11.83	26.50	34.75	45.73	276.50	70.42	115.40
S_8	11.17	28.50	36.18	46.07	297.33	69.15	122.72
S_9	10.50	30.83	36.78	49.22	323.17	66.87	104.22
SEm(±)	**2.34**	**1.48**	**1.12**	**0.95**	**3.76**	**0.66**	**1.60**
LSD(0.05)	**6.74**	**4.27**	**3.24**	**2.73**	**10.83**	**1.91**	**4.60**

Table 3: Effect of sowing time and foliar spray on yield attributes and yield of lentil during *rabi* season

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Test weight (g)	HI
D_1	1306.88	2627.76	20.50	0.33
D_2	867.25	2386.46	19.76	0.26
SEm (±)	**18.93**	**20.33**	**0.04**	**0.00**
LSD (0.05)	**115.21**	**123.68**	**0.22**	**0.03**
S_1	748.61	2241.50	19.45	0.25
S_2	830.83	2441.06	19.60	0.25
S_3	1025.14	2559.63	20.12	0.28
S_4	960.14	2532.29	20.22	0.27
S_5	1099.44	2617.47	20.25	0.29
S_6	1187.36	2392.72	20.30	0.33
S_7	1172.92	2409.94	20.37	0.32
S_8	1431.11	2728.43	20.50	0.34
S_9	1328.06	2640.97	20.37	0.33
SEm (±)	**36.96**	**40.97**	**0.08**	**0.01**
LSD(0.05)	**106.46**	**118.03**	**0.22**	**0.03**

Yield components and seed yield

Both sowing time and foliar spray had had significant influence on number of pods plant, seed and stover yield of lentil (Table 3). Lentil sown on first week of November produced the highest number of pods plant^{-1}(111.07) compared to late sown (December first week) (75.48) during the season. Test weight, being a genetical character, remained unaffected due to variation in sowing time adopted in the investigation. However, foliar spray had some positive effect where B+Fe@0.5 % resulted in a test weight of 20.37 when compared to 19.45 in control (no spray).

Lentil sown on November first week produced the highest seed yield (1306 kg ha^{-1}), which was 33.65 per cent higher over later sowing (December first week) dates, respectively. The yield performances were in accordance with Roy *et al*. (2009) where the first fortnight of November was considered to be the optimum for sowing of lentilcrop in New Alluvial Zone of West Bengal. Among the foliar treatments, B+Fe@0.5 %

resulted in highest yield (1431.11 kg ha^{-1}) followed by B+Zn+Fe@0.5 % (1431.11 kg ha^{-1}) (Fig 1). It should be noted that the no. of flowers although were recorded highest in the treatment with foliar spray of B+Zn+Fe@0.5 %, the competition among the flowers for the source might have resulted in in flower drop thus reducing the number of pods and thus the yield. Stover yield also followed the same trend of seed yield. The highest stover yield (2627.76 kg ha^{-1}) was achieved when sown earlier. The foliar spray with B+Fe@0.5 % resulted in highest stover yield (2728.43 kg ha^{-1}) when compared to 2241.50 kg ha^{-1} in control. The harvest index was recorded highest with the early sowing (0.33). the reduction in various growth and yield attributed resulted in a lesser harvest index of 0.26 in later sown crop (first week of December).

The study conducted revealed that spraying micronutrients especially a mixture of B+Fe@0.5 % and B+Zn+Fe@0.5 % are equally effective in mitigating terminal heat and drought stress. However, the increase in growth and yield attributes might lead to competition among the flowers and thus reducing the pod yield in the case of B+Zn+Fe@0.5 %. This result further need to be validated for concluding further.

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