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SOWING TIME AND MANAGEMENT EFFECTS ON PHENOLOGY, GROWTH AND YIELD OF GARDEN PEA

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Abstract

The experiment was conducted at the research field of the Agronomy Division, Bangladesh Agricultural Research Institute (BARI), Gazipur and Regional Agricultural Research Stations (RARS), Burirhat during two successive *rabi* seasons of 2015 and 17 to find out the relation between different development events of garden pea (*Pisum sativum* L.) and the sowing time based temperature, and also to minimize the yield reduction by adopting appropriate management practices. The treatments comprised with three sowing dates (30 November, 15 December and 30 December) and three management practices (low, medium and high). Under high management, Nov. 30 sowing took maximum days (64 days in 2015-16 and 58 days in 2016-17 at Joydebpur and 58 days in 2015-16 and 57 days in 2016-17 at RARS, Burirhat) to reach harvesting maturity. The results indicated that the number of days required for attaining different phenological stages decreased with delay of sowing. Late sowing took minimum time from flowering to fresh pod maturity (51 days and 49 days in two years at Joydebpur, and 49 days and 46 days in two years at Burirhat) due to increase in minimum temperature. The results revealed that the highest pod yield (14.77 t ha^{-1}in 2015-16 and 13.09 t ha^{-1}in 2016-17 at Joydebpur and 9.63 tha^{-1} in 2015-16 and 10.33 t ha^{-1}in 2016-17 at Burirhat) was recorded from 30 November sowing with high management practices which was followed by 15 December with the same management. Yield reduction in late sowing was reduced to some extent by high management practices. The two year results revealed that 30 November sowing with high management practices (extra 20% recommended fertilizer dose, HRC + two irrigation at pre flowering and pod development stage + seed treatment + one weeding at 21 DAE) showed better pod yield than other combinations.

Introduction

Pea (*Pisum sativum* L.) is commonly used in human diet throughout the world and it is rich in protein (21-25 %), carbohydrates, vitamin A and C, Ca, phosphorous and has high levels of amino acids lysin and trytophan (Bhat *et al*., 2013). Average green pod yield per unit area of the crop in the country is quite low as compared to some other countries. The garden pea is grown mainly for young pod to get tender green seeds as vegetable. The crop has gained popularity for its short durability and high nutritive value. Besides this, a huge amount of garden pea is consumed as soup. Garden pea can play an important role to overcome our national protein deficit. Its demand especially to the urban people is increasing day by day. Edible-pod peas prefer consistently cool growing conditions rather than hotter areas (Slinkard *et al*., 1994).

Among the climatic factors, temperature plays a key role in determining sowing time and consequently the duration of different phenophases and thus the crop productivity (Tewari and Singh, 1993). Further,

delay in sowing may not permit proper vegetative growth of the crop and it may face high temperature at its later growth stages leading to forced maturity and low productivity. Garden pea is a cool loving crop and winter is becoming shorter due to climate change, consequently the crop may be affected. It is mostly grown after aman rice in rice based cropping pattern. Temperature above 30^{o}C is harmful for garden pea (Sousa-Majer *et al*., 2004). Global temperature is rising. Developing seeds exposed to high temperature was found aborted and reduction in pea seed yield (Jeuffroy, 1990). High-temperature stress affects reproductive development, as reported in legumes such as chickpea (*Kaushal et al*., 2013; Kumar *et al*., 2013) and pea (Guilioni *et al*., 1997). It was reported that different environmental conditions, especially temperature due to different sowing time provide variable in crop growth, development and yield stability (Ali *et al*., 2016). It is also needed to minimize the yield reduction by taking different management. So, the experiment was conducted to evaluate the crop growth and yield performance under different management practices.

Materials and Methods

The experiment was conducted at the research field of the Agronomy Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and RARS, Burirhat during *rabi* season of 2015-16 and 2016-17.The soil was silty clay in texture with pH of 6.5. The crops received no rainfall at Joydebpur, Gazipur and RARS, Burirhat during the crop season of 2015-16 and 2016-17. The treatments were comprised with three sowing dates; i. 30 November (D_1), ii. 15 December (D_2) and iii. 30 December (D_3) and management practices; i. Low: 25-30-56-5 kg NPKS/ha, no irrigation, no weeding, no pesticide (M_1). ii. Medium: 25-30-56-5 kg NPKSha^{-1}, one weeding at 21 DAE, two irrigations at pre flowering and pod development stages and spraying pesticides (Dithane M-45) (M_2). iii. High: 30-36-67-6 NPKS kgha^{-1} (Recommended dose + extra 20% recommended dose, HRC+ two irrigation at pre flowering and pod development stage, seed treatment(Seeds were treated with Vitavex-200 @ 2.5 g kg^{-1} seeds before 24 hours of sowing),one weeding at 21 DAE (M_3). The experiment was laid out in a split-plot design with three replications. The sowing dates were assigned in the main plots and management practices were arranged in sub-plots. Garden pea var. BARI motorshuti-3 was used as test crop. Seeds were sown in lines with maintaining 30 cm row to row spacing. Half of urea and full doses of other fertilizers were applied at the time of final land preparation. The remaining half of urea was top dressed at flowering stage followed by irrigation. In case of low management, all fertilizers were applied at the time of final land preparation. Insecticide was sprayed in the respective treatment plots. At flowering stage, plant samples were collected from an area of one square meter of all treatments and the plant samples were dried in an oven for 72 hours at 80^{o}C and then dry weights were recorded. The phenological data were recorded by field monitoring every day. The yield component data was collected from 10 randomly selected plants prior to harvest from each plot. Meteorological data for air temperature and rainfall were obtained from meteorological station located adjacent to the experiment field. At later stage of cropping season rust disease was visible. Rust disease was controlled by Tilt only Joydebpur. At harvest, the yield data was recorded plot wise and analyzed statistically by MSTAT-C and means were compared using Least Significant Difference (LSD).

Results and Discussion

Days for development events

The phenological stages of garden pea may be broadly classified as emergence, flowering, 50% flowering, pod set and fresh pod. The number of days required for different development events of garden pea grown under different sowing dates and management practices over the years and over the locations have been presented in Table 1. All the phonological events varied on sowing dates and management practices. Emergence of early sown crop occurred 1 days earlier than those of late sown. Late sowing reduced the length of vegetative growth stage causing early flowering. The 30 November

sowing took maximum days for first flowering (32 days and 29 days in both the years at Joydebpur and 31 days for two years at Burirhat) and 50% flowering (35 days for two locations in 2015-16 and 31 days in 2016-17 at Joydebpur and 34 days in 2016-17 at Burirhat) whereas 30 December sowing took minimum days for first flowering (26 days in 2015-16 and 28 days in 2016-17 at Joydebpur and 28 days in 2015-16 and 26 days in 2016-17 at Burirhat) and 50% flowering (29 days in two years over the locations).The days for harvesting maturity (fresh pod) varied by sowing date and management practices.

Table 1. Number of days required for attaining different developmental events of garden pea grown at different sowing dates under different management practices during *rabi* season of 2015-16 and 2016-17 at Joydebpur and RARS, Burirhat

Treatments		**Developmental events**							
Sowing dates	**Management**	**Emergence**				**Days to1st flower initiation**			
		2015-16		**2016-17**		**2015-16**		**2016-17**	
		Joy.	**Bur.**	**Joy.**	**Bur.**	**Joy.**	**Bur.**	**Joy.**	**Bur.**
30 Nov.	Low	6	7	6	7	32	31	29	31
	Medium	6	6	6	7	32	31	29	30
	High	6	7	6	7	32	30	29	28
15 Dec.	Low	6	7	6	8	27	28	29	27
	Medium	6	7	6	7	27	28	29	27
	High	6	6	6	7	27	27	29	26
30 Dec.	Low	7	8	8	8	26	27	28	26
	Medium	7	8	8	8	26	27	28	26
	High	7	7	8	7	26	27	28	25

Table 1. Cont'd

Treatments		**Developmental events**							
Sowing dates	**Management**	**Days to 50% flower initiation**				**Fresh pod**			
		2015-16		**2016-17**		**2015-16**		**2016-17**	
		Joy.	**Bur.**	**Joy.**	**Bur.**	**Joy.**	**Bur.**	**Joy.**	**Bur.**
30 Nov.	Low	35	35	31	34	62	58	56	55
	Medium	35	34	31	33	64	60	58	57
	High	35	34	31	32	64	61	58	57
15 Dec.	Low	29	31	31	30	56	53	52	50
	Medium	29	31	31	30	57	54	54	52
	High	29	30	31	30	57	55	55	52
30 Dec.	Low	29	29	29	29	51	49	49	46
	Medium	29	29	29	28	55	52	51	48
	High	29	29	29	27	55	53	51	48

The 30 November sowing took maximum days (64 days in 2015-16 and 58 days in 2016-17 at Joydebpur and 58 days in 2015-16 and 57 days in 2016-17at Burirhat). Low management practices took minimum days for harvesting fresh pod and both the medium and high management practices took maximum days. The minimum days for harvesting maturity were found in 30 December sowing (51 days and 49 days in two years at Joydebpur 49 days and 46 days in two years at Burirhat) at low management practices. The maximum days needed for pod harvest (64 days in 2015-16 and 58 days in 2016-17) was recorded both medium and high management practices at 30 Nov. sowing. The reasons for variation in growth duration might be due to variation in day and night temperature and in increased temperature at the later sowing.

The mean temperatures during crop duration varied across the sowing dates over the years and over the locations (Table 2a and 2b).The late sown crop received comparatively higher temperatures from emergence to 1st flowering and 50% flowering to maturity stages than those of early sown ones. At 30

Dec. sowing, from emergence to 1st flowering the maximum and minimum temperature were (27^0C and 19.60^0C in 2015-16 and 31.35^0C and 12.60^0C in 2016-17), respectively at Joydebpur. From 50% flowering to harvesting maturity the maximum and minimum temperature were (29.65^0C and 11.99^0C in 2015-16 and 30.24^0C and 14.72^0C in 2016-17), respectively at Joydebpur. At 30 Dec. sowing, from emergence to 1st flowering the maximum and minimum temperature were (28.67^0C and 16.00^0C in 2015-16 and 28.70^0C and 16.80^0C in 2016-17), respectively. From 50% flowering to harvesting maturity the maximum and minimum temperature were (22.43^0C and 11.43^0C in 2015-16 and 25.83^0C and 12.06^0C in 2016-17), respectively at Burirhat. Late sown crop produced flower early and also matured early than early sown due to prevailing higher minimum and maximum temperatures. Similar results were also observed by Helena and Brodaczewska (2007).

Table 2a. Average mean temperature for different phonological events of Gardenpea (var. BARI Motorshuti-3) as affected by sowing dates at Joydebpur during *rabi* season of 2015-16

Phenological events	**Sowing dates**					
	30 November		**15 December**		**30 December**	
	Min. Tem. ^{0}C	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**
Emergence (days	18.35	29.02	17.50	24.00	15.40	26.80
Emergence to1st flowering	16.30	27.40	18.00	24.00	19.60	27.00
First flowering to 50% flowering	12.40	26.70	16.23	26.03	10.93	26.15
50% flowering to harvesting maturity(fresh pod)	11.93	24.73	12.38	25.68	11.99	29.65

Table 2a. Average mean temperature for different phenological events of Gardenpea (var. BARI Motorshuti-3) as affected by sowing dates at Joydebpur during *rabi* season of 2016-17

Phenological events (Days)	**Sowing dates**					
	30 November		**15 December**		**30 December**	
	Min. Tem. ^{0}C	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**
Emergence	16.73	30.67	14.83	27.38	12.43	27.48
Emergence to1st flowering	14.74	28.16	13.15	26.75	12.42	27.45
First flowering to 50% flowering	13.00	28.06	11.33	27.46	12.60	31.35
50% flowering to harvesting (fresh pod)	11.56	26.43	13.36	28.11	14.72	30.24

Table 2b. Average mean temperature for different phonological events of Gardenpea (var. BARI Motorshuti-3) as affected by sowing dates at RARS, Burirhat during *rabi* season of 2015-16

Phenological events	**Sowing dates**					
	30 November		**15 December**		**30 December**	
	Min. Tem. ^{0}C	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**	**Min. Tem. ^{0}C**	**Max. Tem. ^{0}C**
Emergence (days	17.80	28.73	17.80	28.73	16.23	27.53
Emergence to1st flowering	16.00	28.67	16.40	26.07	16.20	25.60
First flowering to 50% flowering	15.90	20.67	13.53	24.93	11.50	23.40
50% flowering to harvesting maturity(fresh	11.43	22.43	12.47	24.33	13.33	26.73

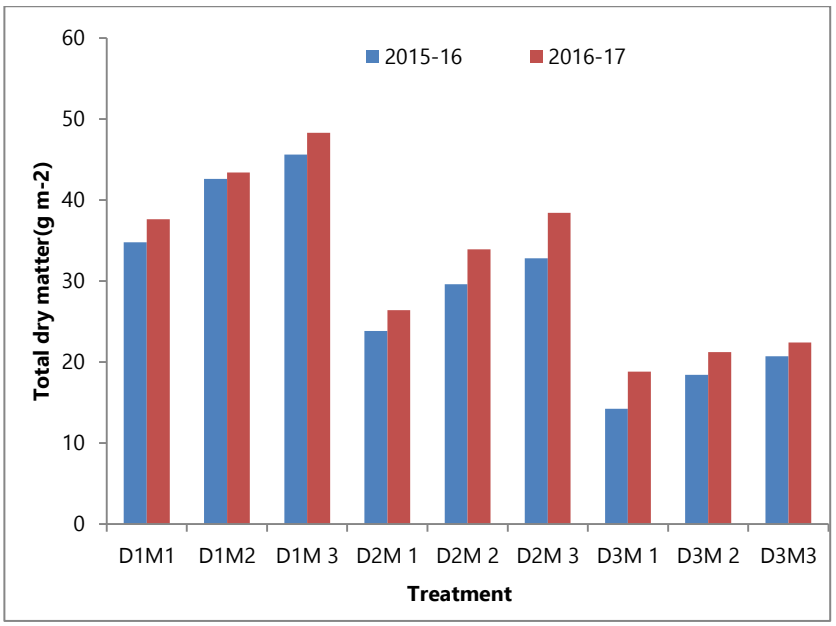
pod)

Table 2b. Average mean temperature for different phonological events of Gardenpea (var. BARI Motorshuti-3) as affected by sowing dates at RARS, Burirhat during *rabi* season of 2016-17

Phenological events (Days)	Sowing dates					
	30 November		15 December		30 December	
	Min. Tem. ^{0}C	Max. Tem. ^{0}C	Min. Tem. ^{0}C	Max. Tem. ^{0}C	73	Max. Tem. ^{0}C
Emergence	17.00	28.70	16.87	28.70	16.43	28.60
Emergence to1st flowering	16.80	28.70	16.40	28.33	15.47	28.00
First flowering to 50% flowering	12.13	25.33	11.60	24.00	13.90	27.77
50% flowering to harvesting (fresh pod)	12.06	25.83	12.76	26.47	14.17	27.86

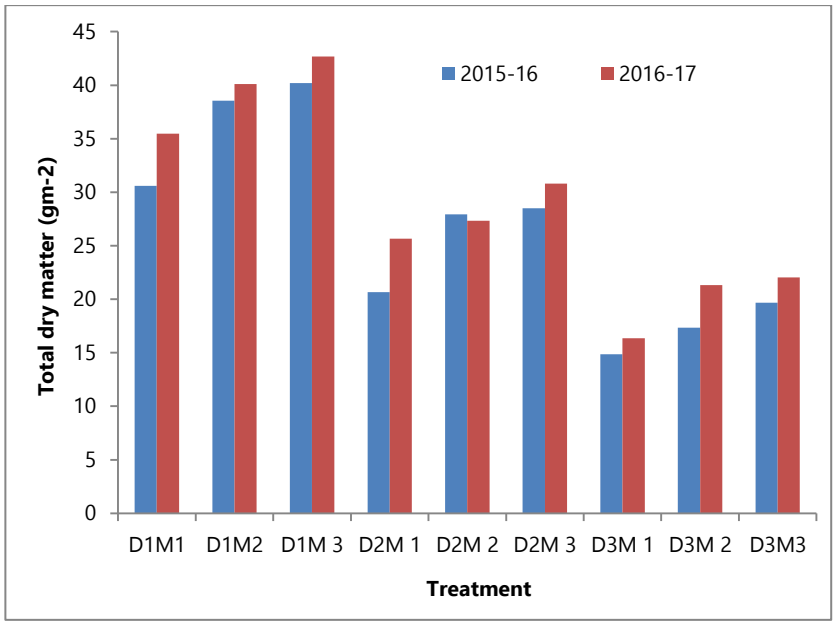
Total dry matter

At, flowering stage, the total dry matter production of garden pea varied due to different sowing dates and management practices (Fig.1a and 1b) over the years over the locations. At Joydebpur, significantly the highest total dry matter (46.5gm^{-2}in 2015-16 and 41.93 gm^{-2}in2016-17) was recorded in 30 November sowing with high management practices. The lowest total dry matter (14.68 g m^{-2}in 2015-16 and20.79 g m^{-2} in 2016-17 and) was recorded at 30 December sowing with low management practices which was identical with medium management practices at the same date of sowing. On the other hand, at Burirhat, the highest total dry matter (40.20 gm^{-2}in 2015-16 and 42.67gm^{-2}in 2016-17) was recorded in 30 November sowing with high management practices. The lowest total dry matter (14.86 g m^{-2}in 2015-16 and 16.34 g m^{-2} in 2016-17) was recorded in 30 December sowing with low management practices which was identical with medium management practices at the same date of sowing.



D_1= 30 Nov. D_2= 15 Dec. D_3= 30 Dec., M_1=Low management, M_2=Medium management, M_3= High management

Fig.1a. Total dry matter production of gardenpea at flowering stage under different sowing dates and management practices during 2015-16 and 2016-17 at Joydebpur.



D_1= 30 Nov. D_2= 15 Dec. D_3= 30 Dec., M_1=Low management, M_2=Medium management, M_3= High management

Fig. 1b. Total dry matter production of gardenpea at flowering stage under different sowing dates and management practices during 2015-16 and 2016-17 at RARS, Burirhat.

Yield and yield attributes

Plant population, plant height, number of pods plant^{-1}and pod yield were significantly different by different sowing dates and management practices over the location over the years (Table 3). Maximum population (14 plant m^{-2} in 2015-16 and 16 plant m^{-2} in 2016-17) was recorded in 30 December sowing with high management practices and the lowest (13 plant m^{-2}) recorded from 30 November sowing with low management practices at Joydebpur. On the other hand, maximum population (15.72plant m^{-2} in 2015-16 and 14.72 plant m^{-2} in 2016-17) was recorded in 30 November sowing with high management practices at Burirhat. The tallest plant was recorded from 30 November sowing with high management practices (48.33 cm and 43.70 cm in two years at Joydebpur and 45.20 cm in 2015-16 and 52.00 cm in 2016-17 at Burirhat) which was identical with medium management practices at the same date of sowing (47.67 cm in 2016-17 at Burirhat). The shortest plant was recorded from 30 December sowing with low management practices (36.78 cm in 2015-16 and 32.83 cm in 2016-17 at Joydebpur and 33.13 cm in 2015-16 and 37.16 cm in 2016-17 at Burirhat). Significantly the highest number of pods (16.67 plant^{-1}in 2016-16 and 13.45 plant^{-1}in 2016-17 at Joydebpur and 19 plant^{-1} in 2015-16 and 15.00 plant^{-1} in 2016-17 at Burirhat) was recorded in 30 November sowing with high management practices while lowest number of pod in 30 December sowing with low management practices.

Pod yield of garden pea varied significantly under different sowing dates and management practices. Pod yield of garden pea was more at November 30 sowing and decreased towards late sowing. The maximum pod yield also recorded from 30 November sowing with high management practices (14.77 tha^{-1} in 2015-16 and 13.09 t ha^{-1}in 2016-17 at Joydebpur and 9.63 t ha^{-1}in 2015-16 and 10.33 t ha^{-1}in 2016-17 at Burirhat) which was followed by 15 Dec. sowing of same management practices. The lowest pod yield was obtained from 30 December sowing with low management practices (8.90 t ha^{-1}in

2015-16 and 8.70 t ha^{-1}in 2016-17 at Joydebpur and 5.58 t ha^{-1} in 2015-16 and 5.00 t ha^{-1} in 2016-17 at Burirhat). The lower pod yield at 30 December sowing might be due to prevailing high temperature during flowering to maturity (Fig. 2a and 2b and Fig.3a and 3b) that hastens forced maturity and reduced TDM production and translocation to the yield components. Similar results were recorded by Ali *et al*. (2016).

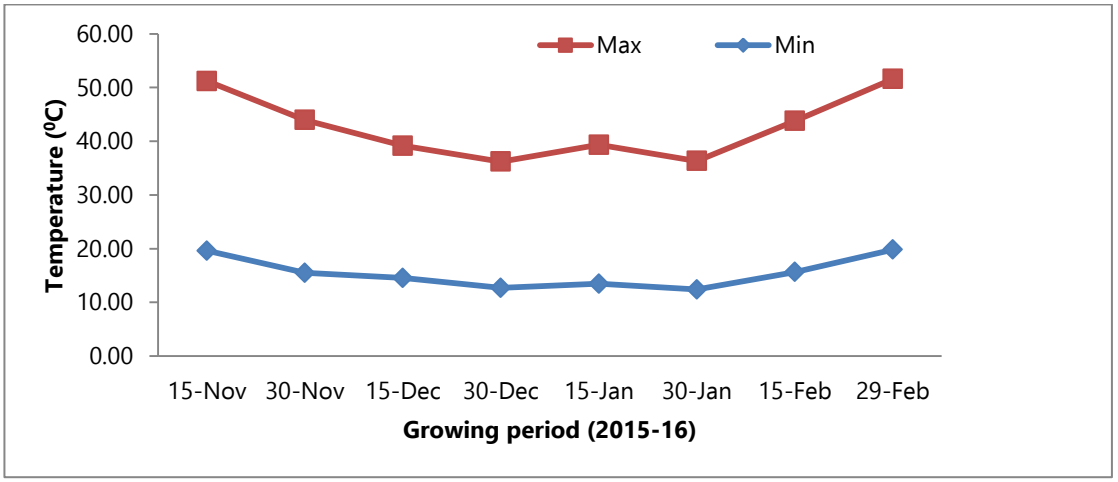


Fig 2a. Maximum and minimum temperature during growing period (2015-2016) at BARI, Joydebpur, Gazipur.

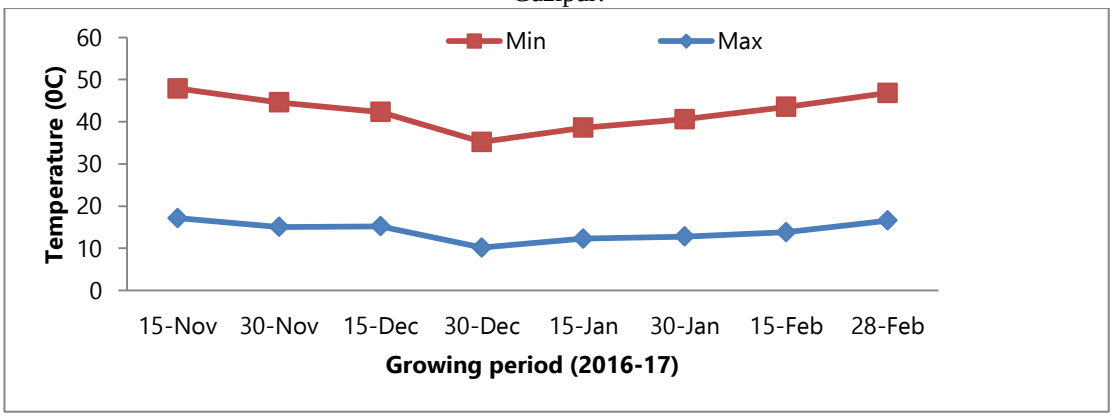


Fig 2b. Maximum and minimum temperature during growing period (2016-2017) at BARI, Joydebpur, Gazipur.

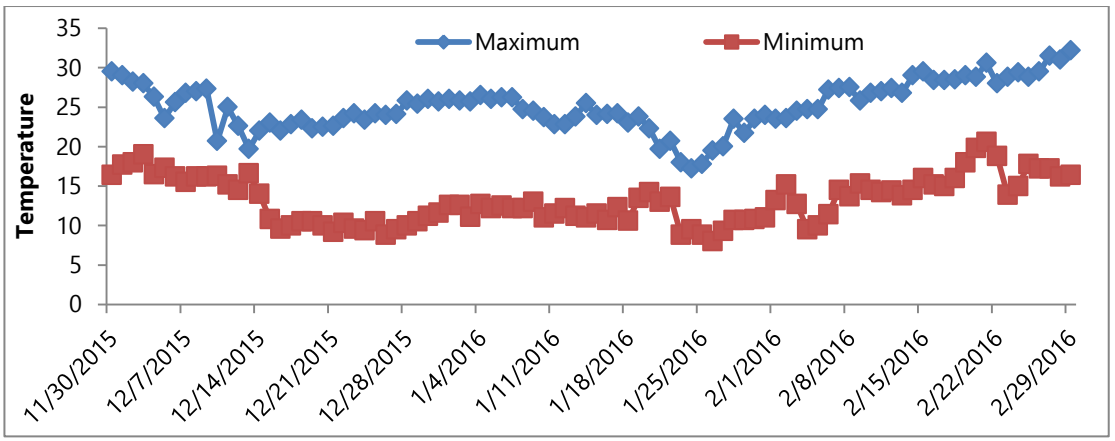


Fig 3a. Weekly mean temperatures (max. and min.) during crop growing period 2015-16 at BARI, RARS, Burirhat.

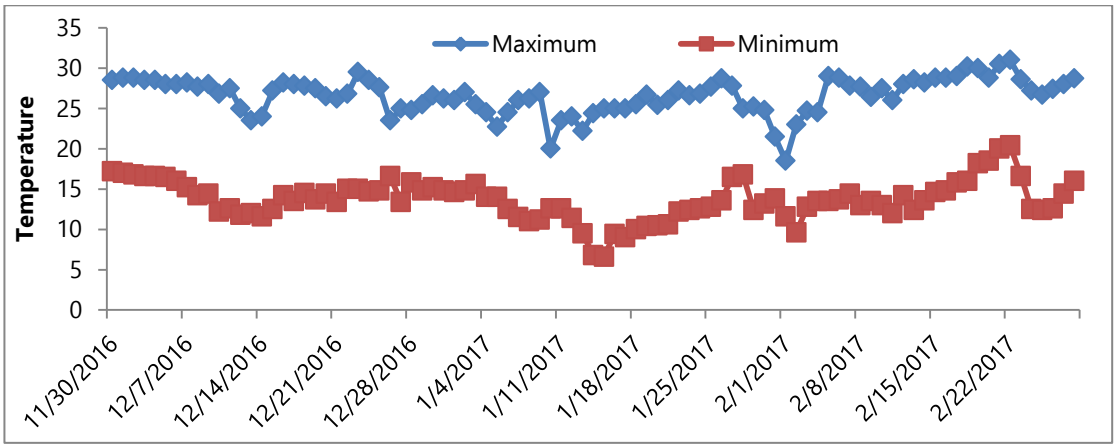


Fig 3b. Weekly mean temperatures (max. and min.) during crop growing period 2016-17 at BARI, RARS, Burirhat.

This study indicated that raise in temperature reduced the grain growth duration resulted in yield reduction, which in agreement with the findings of Mohanty *et al*. (2001). It was observed that the pod yield of Dec. 30 sowing was increased from 8.70 to 10.18 t ha^{-1} through high management practices. It was noted that the crop was partially damaged by rust disease before harvest that resulting poor yield in all treatments at Joydebpur.

Table 3. Plant population, plant height and yield contributing characters and yield of garden pea grown at different sowing dates under different management practices at Joydebpur and RARS, Burirhat during *Rabi* season 2015-16 and 2016-2017

Treatments	Plant population m^{-2}				Plant height(cm)			
	Joydebpur		Burirhat		Joydebpur		Burirhat	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
D_1M_1	10.69	12.67	13.11 d	11.11 d	44.62	39.16	34.60 cd	38.40 d
D_1M_2	10.55	14.00	14.27 b	13.07 b	46.78	42.00	40.63 b	43.80 bc
D_1M_3	9.67	14.67	15.72 a	14.12 a	48.33	43.70	45.20 a	52.00 a
D_2M_1	10.95	14.33	14.46 b	10.56 d	42.03	37.09	33.07 d	37.60 d
D_2M_2	11.11	15.00	14.32 b	12.62 c	44.02	39.26	36.13 bc	41.80 cd

D_2M_3	10.11	15.33	15.03 a-c	12.83 bc	45.32	42.25	42.33ab	47.67 ab
D_3M_1	12.44	15.00	13.44 d	10.44 d	36.78	32.83	33.13 d	37.16 d
D_3M_2	12.22	15.33	14.56 b	11.56 d	38.17	34.19	35.67 c	38.40 d
D_3M_3	14.00	16.00	15.10 a-c	11.10 d	39.61	36.56	37.67 bc	41.73 cd
LSD	1.23	1.72	*	*	4.66	0.12	*	*
CV (%)	6.12	6.61	5.21	3.34	6.69	6.75	5.05	6.51

Cont'd

Treatments	**Pods plant^{-1}(no.)**				**Pod yield tha^{-1}**			
	Joydebpur		**Burirhat**		**Joydebpur**		**Burirhat**	
	2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
D_1M_1	12.53	11.91	10.73 d	10.27 d	11.03	10.90	6.86 cd	5.80 e
D_1M_2	15.00	12.87	11.00 bc	12.60 bc	12.47	12.45	8.68 ab	8.44 b
D_1M_3	16.67	13.45	14.27 a	15.00 a	14.77	13.09	9.63 a	10.33 a
D_2M_1	10.69	11.55	12.87 bc	11.00 d	10.17	10.17	6.37 cd	6.38 de
D_2M_2	13.07	12.06	11.80 bc	12.90 c	11.50	12.15	7.41 bc	6.70 de
D_2M_3	14.20	13.09	14.07 ab	13.20 b	13.63	12.75	9.33 a	9.07 ab
D_3M_1	7.20	7.18	10.00 d	9.60 d	8.98	8.70	5.58 cd	5.00 f
D_3M_2	7.57	8.86	10.33 d	11.93 c	10.08	9.58	5.71 cd	6.70 de
D_3M_3	8.78	9.89	11.27 cd	12.00 c	11.50	10.18	5.10 d	7.44 cd
LSD(0.05)	1.11	0.50	*	*	0.52	0.36	*	*
CV (%)	5.30	5.95	6.74	9.60	5.54	5.81	3.66	6.32

D_1= 30 Nov. D_2= 15 Dec. D_3= 30 Dec., M_1=Low management, M_2=Medium management, M_3= High management

Conclusion

The results revealed that temperature variation in different sowing dates influenced highly on phenology, growth and yield of garden pea. Increased temperature enhanced early flowering of late sown garden pea. High temperature from flowering to maturity reduced duration of pod setting and produced lower yield at 30 Dec. sowing. The pod yield reduction was reduced to some extent by high management practices. Two year results revealed that 30 November sowing with high management practices (extra 20% recommended fertilizer dose, HRC + two irrigation at pre flowering and pod development stage + seed treatment + one weeding at 21 DAE) showed better pod yield than other combinations.

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