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Impact of Sowing Time on Thermal Utilization of Grass Pea in New Alluvial Zone of West Bengal

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ABSTRACT

Field experiment was conducted to investigate the impact of sowing dates on thermal utilization of grass pea at Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. Grass pea was sown on nine different dates (D_1 to D_9) from 26th October to 21st December at weekly interval. Accumulated thermal indices viz. Growing degree days (GDD) or Heat units (HU), Heliothermal units (HTU) and Photothermal units (PTU) were computed for pre-flowering phase, post-flowering phase and entire growing period. Thermal use efficiencies were evaluated both in terms of grain yield and leaf and stem weight. D_4 (sowing on 16th November) produced highest grain yield (99.44 g m^{-2}) and leaf and stem weight (33.63 g m^{-2}). Grain yield was positively correlated with the thermal indices accumulated during pre-flowering phase wherein GDD showed highest correlation (r = 0.81) followed by PTU (r = 0.75) and HTU (r = 0.44). Thermal use efficiencies (HUE: Heat unit use efficiencies; HTUE: Heliothermal use efficiencies and PTUE: Photothermal use efficiencies) varied form one treatment to another as affected by varying dates of sowing. D_4 showed highest thermal use efficiencies both in terms of grain yield (HUE: 0.0592 g m^{-2} day^{0}C^{-1}; HTUE: 0.0095 g m^{-2} ^{0}C hour^{-1}; PTUE: 0.0054 g m^{-2} ^{0}C hour^{-1}) and leaf and stem weight (HUE: 0.0200 g m^{-2} day^{0}C^{-1}; HTUE: 0.0032 g m^{-2} ^{0}C hour^{-1}; PTUE: 0.0018 g m^{-2} ^{0}C hour^{-1}). Results revealed that sowing time greatly influence accumulation and utilization of thermal indices in grass pea.

Key words: *GDD, Grass pea, HTU, Sowing date, Thermal use efficiencies.*

INTRODUCTION

Grass pea (*Lathyrus sativus* L.) is a multipurpose grain legume with an indeterminate growth habit. This is a hardy crop and is well adapted to adverse environments such as drought, flood etc. It thrives well with minimal external inputs. Development of grass pea during its entire growth period is greatly affected by several agro-climatic factors. Onset and duration of a particular growth stage are significantly influenced by weather parameters. Durations of different growth stages become shortened at warmer temperatures and grain yield is reduced when the growth stages become shorter which was reported by Craufurd *et al*[2].

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The onset of a particular phenological event in the crop growing period greatly depends on the accumulation of thermal indices viz. Growing degree days (GDD), Heliothermal units (HTU) and Photothermal units (PTU). These are also called agro-meteorological indices. Accumulation of different thermal indices during a growth phase varies according to the sowing time of the crop. Grain yield and dry matter production are altered due to the variations in accumulated thermal indices during the growing period of the crop. Sowing time alters thermal utilization of crop which was demonstrated by Rao *et al.*[10]. This study was conducted to investigate the impact of sowing times on the thermal utilization of grass pea.

MATERIALS AND METHODS

One field experiment was conducted at Instructional Farm (22°58´ N and 88°31´ E), Bidhan Chandra Krishi Viswavidyalaya, West Bengal during winter season of 2016-2017 with grass pea (variety: 'Prateek') sown on nine dates (D_1: 26th October; D_2: 2nd November; D_3: 9th November; D_4: 16th November; D_5: 23rd November; D_6: 30th November; D_7: 7th December; D_8: 14th December and D_9: 21st December). The experiment was carried out in Randomized complete block design (RCBD) with three replications. Line sowing was done with 40 kg/ha seed rate and a row spacing of 30 cm was maintained. Recommended fertilizer dose was applied to the crop. After harvesting of the crop, grain yield (g m^{-2}) and leaf and stem weight (g m^{-2}) were recorded separately. The entire crop growing season was divided into two distinct phases viz. pre-flowering (sowing to flowering) and post-flowering (flowering to harvest maturity) phases. Agro-meteorological indices i.e. GDD, HTU and PTU were computed during pre-flowering, post-flowering and whole growing phases following the methods adopted by Khan *et al*.[4].

Computation of agrometeorological indices:

Growing degree day (GDD) = ($\overline{T}_m - T_b$)

Helothermal unit (HTU) = [($\overline{T}_m - T_b$) x BSH]

Photothermal unit (PTU) = [($\overline{T}_m - T_b$) x DL]

Where,

DL = Day length (Possible sunshine hours: from dawn to twilight)

BSH = Bright sunshine hours (Hour)

T_m= Daily mean temperature in °C.

T_b = Base temperature of 5°C.

Thermal use efficiencies were evaluated in terms of both grain yield and leaf and stem weight by using the formula adopted by Tzudir *et al.*[10].

Thermal use efficiencies = (Grain yield or Leaf and stem weight / Accumulated thermal indices)

RESULTS AND DISCUSSION

Accumulated thermal indices

Results revealed variations in the accumulation of thermal indices during per-flowering, post-flowering phases and entire growing season under different dates of sowing. Accumulated Growing degree day (AGDD) over the entire crop growing season has been presented in table 1. During pre-flowering phase, the highest AGDD (722.5 day ^{0}C) was required by the crop sown on D_5 and the crop sown on D_7 needed the lowest AGDD (590.2 day^{0}C). During post-flowering phase, the crop sown on D_1 needed the highest GDD (1137.2 day^{0}C), whereas the lowest AGDD (971.7 day^{0}C) was required by the crop sown on D_6. When the whole growing season was considered, AGDD was the highest (1838.8 day^{0}C) in the crop sown on D_1 and lowest (1582.3 day^{0}C) in the crop sown on D_9. AGDD showed decreasing trend from D_1 to D_4 then it slightly increased and thereafter AGDD again started to reduce till D_9. Accumulated Heliothermal units (AHTU) and accumulated Photothermal units (APTU) has been presented in table 2 and table 3 respectively. AHTU and APTU varied greatly with variations in the sowing dates. Highest AHTU and APTU during entire growing season were found to be maximum in D_1 (AHTU = 11950.5 ^{0}C hour; APTU = 20042.4 ^{0}C hour). Minimum AHTU (10190.9 ^{0}C hour) was accumulated in D_8 while minimum APTU (17976.2 ^{0}C hour) was accumulated in D_9. Variation in accumulation of GDD and HTU under varying sowing times in rapeseed was demonstrated by Akhter *et al.*[1]. The values of standard deviation and coefficient of variance of accumulated thermal indices have been presented in table 4.

Grain yield (g m^{-2}) and leaf and stem weight (g m^{-2})

Variation of grain yield and leaf and stem weight under different sowing dates has been presented in Table 5. Grain yield varied from 62.09 g m^{-2} in D_9 to 99.44 g m^{-2} in D_4. D_4 showed highest grain yield which was statistically at par with D_3 (86.53 g m^{-2}), D_5 (96.89 g m^{-2}) and D_6 (87.32 g m^{-2}). Leaf and stem weight was the highest in D_4 (33.63 g m^{-2}) which was statistically at par with D_1 (29.52 g m^{-2}), D_2 (30.72 g m^{-2}), D_3 (33.18 g m^{-2}) and D_5 (29.13 g m^{-2}). Leaf and stem weight was found to be the lowest in D_9 (15.74 g m^{-2}). Both grain yield and leaf and stem weight showed increasing trend from D_1 to D_4 and then these started to reduce till D_9. Reduction in the yield was reported earlier in chickpea by Krishnamurthy *et al.*[7], Neeraj *et al.*[8], Devendra *et al.*[3] and Wang *et al.*[11].

Effect of accumulated thermal indices on grain yield and leaf and stem weight

Values of correlation coefficients (r) indicated the effect of accumulated thermal indices on grain yield and leaf and stem weight. Results revealed that grain yield exhibited positive correlations (Table 6) with all thermal indices accumulated during pre-flowering phase (AGDD: r = 0.81**; AHTU: r = 0.44; APTU: r = 0.75*). Grain yield showed negative correlations with accumulated thermal indices during post-flowering phase though the correlations were not significant (AGDD: r = -0.01; AHTU: r = -0.04; APTU: r = -0.26). Leaf and stem weight of grass pea showed positive correlations with the thermal indices during both pre-flowering and post-flowering phases (Table 6).

Grain yield showed polynomial relationship with GDD accumulated during pre-flowering phase (Fig.1). The value of coefficient of determination (R^2) was 0.674* which indicated that AGDD of pre-flowering phase could explain 67.4% of the total variability in grain yield of grass pea. It was clear from the results that grain yield exhibited polynomial relationship with AHTU of pre-flowering phase also with R^2 value of 0.593* (Fig.2). Kiran *et al.*[6]. reported variation in yield and yield components depending on the temperature regime.

Leaf and stem weight of grass pea was also polynomially related with AGDD and AHTU of pre-flowering phase with R^2 values of 0.946** in case of AGDD (Fig.3) and 0.959** in case of AHTU (Fig.4). Thus AGDD and AHTU could explain 94.6% and 95.9% respectively of the total variations in leaf and stem weight.

Thermal use efficiencies

Thermal use efficiencies in terms of grain yield and leaf and stem weight have been presented in table 7. Heat unit use efficiencies (HUE), heliothermal use efficiencies (HTUE) and photothermal use efficiencies (PTUE) were highest in D_4 both in terms of grain yield (HUE: 0.0592 g m^{-2} day^{0}C^{-1}; HTUE: 0.0095 g m^{-2} ^{0}C hour^{-1}; PTUE: 0.0054 g m^{-2} ^{0}C hour^{-1}) and leaf and stem weight (HUE:0.0200 g m^{-2} day^{0}C^{-1}; HTUE: 0.0032 g m^{-2} ^{0}C hour^{-1}; PTUE: 0.0018 g m^{-2} ^{0}C hour^{-1}). D_9 showed lowest thermal use efficiencies both in terms of grain yield and leaf and stem weight. Results revealed after D_4, thermal use efficiencies reduced with delayed sowing. This result was supported by Kingra *et al.*[5] who reported variations in thermal use efficiencies under varied sowing dates in ground nut.

Table 1: Accumulation of GDD (day °C) in grass pea under different sowing dates

Growth stages	Treatments (Dates of sowing)									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	Mean
Pre-flowering	701.6	681.1	664.6	682.1	722.5	658.4	612.1	609.9	590.2	658.0
Post-flowering	1137.2	1129.1	1114.3	997.9	978.2	971.7	1011.6	1003.1	992.1	1037.2
Entire growing period	1838.8	1810.2	1778.9	1680.0	1700.7	1630.1	1623.6	1613.0	1582.3	1695.3

Table 2: Accumulation of HTU (°C hour) in grass pea under different sowing dates

Growth stages	Treatments (Dates of sowing)									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	Mean
Pre-flowering	4756.1	4765.3	4258.6	3971.5	4518.2	4178.8	3711.7	3641.4	3811.0	4179.0
Post-flowering	7194.4	6992.2	7035.2	6490.7	6350.8	6298.8	6514.8	6549.5	6422.3	6649.8
Entire growing period	11950.5	11757.5	11293.8	10462.2	10869.0	10477.6	10226.5	10190.9	10233.2	10829.0

Table 3: Accumulation of PTU (°C hour) in grass pea under different sowing dates

Growth stages	Treatments (Dates of sowing)									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	Mean
Pre-flowering	7613.4	7332.3	7105.0	7261.6	7693.8	7018.2	6540.5	6549.3	6369.5	7053.7
Post-flowering	12429.0	12442.7	12408.3	11209.6	11154.7	11137.3	11681.7	11673.3	11606.7	11749.2
Entire growing period	20042.4	19774.9	19513.2	18471.2	18848.5	18155.5	18222.3	18222.5	17976.2	18803.0

Table 4: Standard deviation (S.D.) and coefficient of variance (C.V.) of accumulated GDD, HTU and PTU

Growth stages	AGDD		AHTU		APTU	
	S.D. (±)	C.V. (%)	S.D. (±)	C.V. (%)	S.D. (±)	C.V. (%)
Pre-flowering	45.1	6.8	430.7	10.3	478.8	6.8
Post-flowering	68.5	6.6	331.7	5.0	550.8	4.7
Entire growing period	93.5	5.5	682.0	6.3	780.6	4.2

Table 5: Variation in grain yield (g m-2) and leaf and stem weight (g m-2)
as affected by varied dates of sowing

Dates of sowing	Grain yield (g m^{-2})	Leaf and stem weight (g m^{-2})
26th October	80.7	295.2
2nd November	84.0	307.2
9th November	86.5	331.8
16th November	99.4	336.3
23rd November	96.8	291.3
30th November	87.3	194.0
7th December	79.4	169.5
14th December	68.3	162.6
21st December	62.1	157.4
C.D. (5%)	13.412	93.141
SEm (±)	4.435	30.803
C.V. (%)	9.286	19.9

Table 6: Correlation coefficients of grain yield and leaf and stem weight with thermal indices accumulated during pre-flowering, post-flowering and entire growth period

Growth stages	Grain yield			Leaf and stem weight		
	GDD	HTU	PTU	GDD	HTU	PTU
Pre-flowering	0.81	0.44	0.75	0.82	0.69	0.82
Post-flowering	-0.01	-0.04	-0.26	0.55	0.54	0.33
Entire growing period	0.38	0.26	0.28	0.80	0.70	0.74

Table 7: Thermal use efficiencies in terms of grain yield and leaf and stem weight

Dates of sowing	In terms of grain yield			In terms of leaf and stem weight		
	HUE ($g\ m^{-2}\ day^{0}C^{-1}$)	HTUE ($g\ m^{-2}\ {}^{0}C\ hour^{-1}$)	PTUE ($g\ m^{-2}\ {}^{0}C\ hour^{-1}$)	HUE ($g\ m^{-2}\ day^{0}C^{-1}$)	HTUE ($g\ m^{-2}\ {}^{0}C\ hour^{-1}$)	PTUE ($g\ m^{-2}\ {}^{0}C\ hour^{-1}$)
26th October	0.0439	0.0068	0.0040	0.1605	0.0247	0.0147
2nd November	0.0464	0.0071	0.0042	0.1697	0.0261	0.0155
9th November	0.0486	0.0077	0.0044	0.1865	0.0294	0.0170
16th November	0.0592	0.0095	0.0054	0.2002	0.0321	0.0182
23rd November	0.0570	0.0089	0.0051	0.1713	0.0268	0.0155
30th November	0.0536	0.0083	0.0048	0.1190	0.0185	0.0107
7th December	0.0489	0.0078	0.0044	0.1044	0.0166	0.0093
14th December	0.0423	0.0067	0.0037	0.1008	0.0160	0.0089
21st December	0.0392	0.0061	0.0035	0.0995	0.0154	0.0088

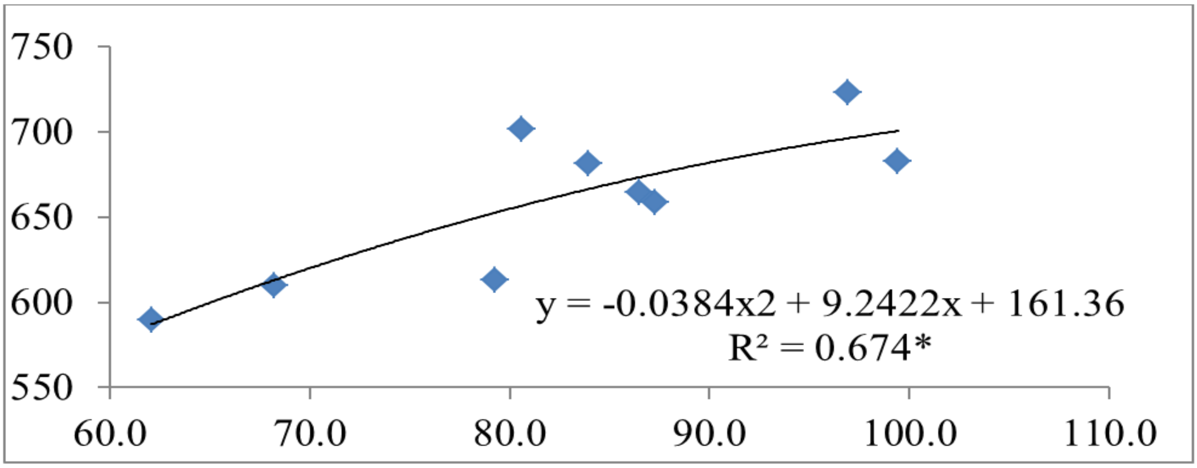

Fig. 1: Relationship between grain yield (g m-2) and GDD (day °C) accumulated during pre-flowering phase

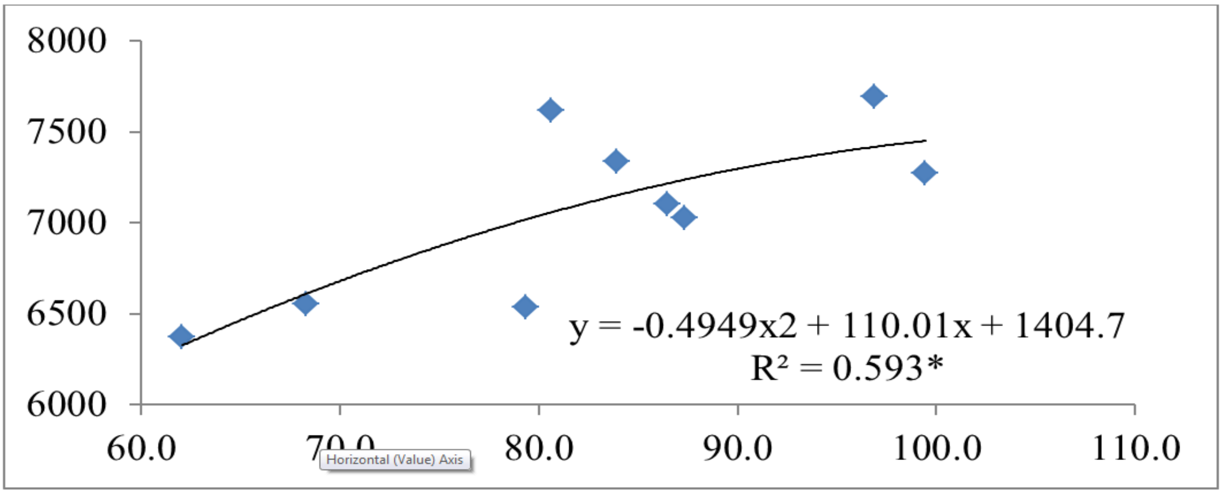

Fig. 2: Relationship between grain yield (g m-2) and HTU (°C hour) accumulated during pre-flowering phase

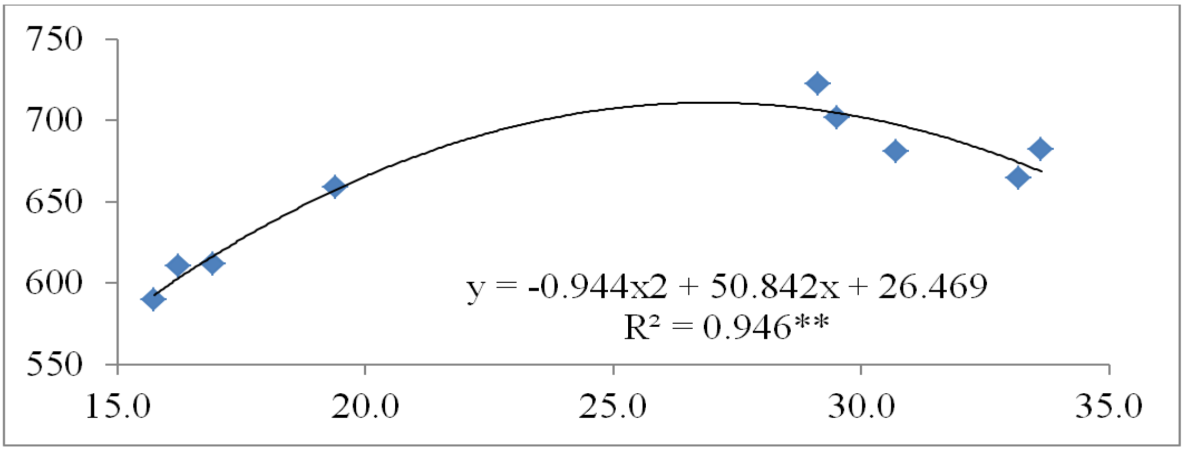

Fig. 3: Relationship between leaf and stem weight (g m-2) and GDD (day °C) accumulated during pre-flowering phase

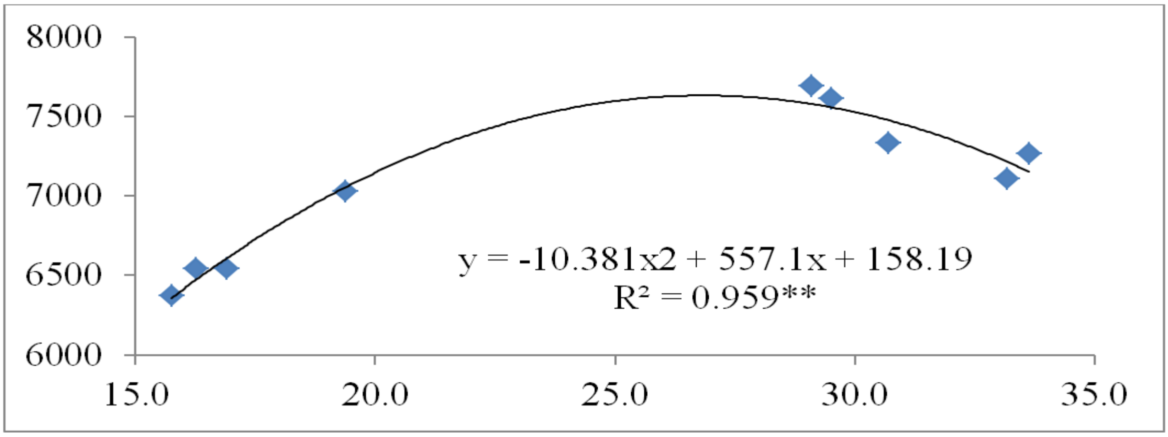

Fig. 4: Relationship between leaf and stem weight (g m-2) and HTU (°C hour) accumulated during pre-flowering phase

CONCLUSIONS

From the experiment it can be concluded that accumulation of thermal indices varied with sowing time. Grain yield was positively correlated with the thermal indices accumulated during pre-flowering phase while it was negatively correlated with thermal indices accumulated during post-flowering phase. Thermal indices accumulated during both pre-flowering and post-flowering phases had beneficial effects on leaf and stem weight. The crops sown during November had more thermal use efficiencies as compared to the crops sown on other dates. It may be inferred that sowing time played very significant role in thermal utilization of grass pea.

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