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THE INFLUENCE OF TEMPERATURE ON PHENOLOGY, GROWTH AND YIELD OF PISUM SATIVUM L.

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ABSTRACT

Pisum sativum L.plants need,1337, 5495, 4157, 8357, and 21086 photothermal unit (PTU), 205, 890, 684, 1377 and 2819 total day temperature (TDT), 149, 674, 524, 1032 and 2121 total night temperature (TNT) and 60, 227, 166,354 and 713 total daily range (TDR) for the different phenological stages, i.e. from sowing to emergence, sowing to 1st flower, emergence to 1st flower, sowing to 50% flowering and sowing to maturity, respectively.

Pisum sativum cultivars (Alderman, Alaska and Perfection) differed significantly in length of some growth stages.Summation took similar trend in most stages. *Pisum sativum* plants need 129, 517, 788 and 1798 growing degree days (GDD); 90, 391, 654, and 1315 total bright sunshine hours (TBSSH) and 114, 577, 925 and 1856 potential sunshine hours (PSSH) for the different phenological stages. This summation could be used for predicting of temperature in a certain location, and consequently the expected date of maturity of a certain variety could be known. Cultivars differed significantly in yield and its components, protein and other agronomic characters. Alderman cv. was superior in the efficiency of energy conversion than the two other cultivars.

INTRODUCTION

Temperature is a major environmental factor that determines the rate of plant development (*Johnson and*

Thornley, 1985, McCould, 1984). With the building of growth and development models, there has been renewed interest in estimates of plant phenological stages. Temperature is a main driver of phenological progress through vegetative and reproductive stages of many species. These could be linked to thermal time (*Whisler et al.,1986)*

Thermal time has been used to follow the progress of plant ontogeny from emergence to maturity and to describe development at individual organs. Studies of development of spring wheat (*Angus et al.,1981b)* and faba beans *(Faiza, 1989)* had shown a clase relationship of phenological stage with temperature and thermal time CD.

In controlled environment experiments, rates of Pisum sativum development were determind by temperature *(Skjelvag, 1981 b)*,and weight increase correlated linearly with temperature. However, at lower temperature, longer fruitfilling periods are required *(Imam, 1988).Angus* et al. (1981 a) examined thermal time from planting to emergence in field experiments for 44 species, including three Pisum sativum cultivars.For most species, a linear relationship existed between rate of development and day-degree. *Labudo (1987)* states that sum of temperatures from sowing until emergence was an average 222°C, on the other hand, the mean sum of temperatures and mean time from sowing until emergence of Pisum sativum varied significantly among years. In addition, *Ellis et al.(1988)* found that optimum temperature for mean rate of seedling emergence was 23.9°C and for rate of progress towards flowering was 25.4°C in Alaska.

The effects of climatic factors on the growth and development of field bean in phytotrone and open field experiments showed different trends for the phenological phases and growth. Rates of phenological development which were predominantly affected by day-time temperature during all phases, *(Skjelvag, 1981 a)*.

Variation in soil moisture and shading throughout the growth period had no significant effect on the seed nitrogen percentage of Pisum sativum *(Tanaki and Naka, 1971)*. *Skjelvag (1981 b)* found that seed N content increased with temperature increase from 15 to 18 or 21 °C and fell again at 24 °C. On the other hand, the narrow spacings between hills and higher number of plants per hill gave greater total protein yield per faddan as reported by *Shalaby and Mohamed (1978)*.

The effect of some climatic factors on growth and yield was studied on some field crops by *Imam (1988)*, *Seeman and Lomes (1979)*, *Boyer(1982)*, *Debace et al.,(1985)*, *Rady (1986)*, *El-Shaer(1988) and Faiza(1989)* who found significant correlation between microclimatic variables and yield. Yield component and protein [illegible] ut different in direction.

[illegible] to study the energy summation indices of some phenological stages and performance for three cultivars as influenced by number of plants/hill and the growth, as well as, the relationships between yield and this energy.

MATERIALS AND METHODS

Field experiments were conducted at special farm at Dakahliya Province, Egypt during 1991/ 1992 season.

Three Pisum sativum cultivars were planted on Nov. 12th and 13th in 1991, respectively. The cultivars were Alderman, Alaska and Perfection.

Two planting densities were tried where two or three plants/hill where left to have 22.22 or 33.33 plants/m^2, respectively. Planting was made on both sides on ridges 60 cm apart. The experiment was laid out in split plot design with four replications. The main plots received cultivars and the sub-plots were devoted to no. of plants/hill, (sub-plot area = $10.5m^2$). The normal cultural growth for this crop was practised, and the following characters were determined.

A- Phenological stage:

Development was measured related to time was followed according to *Skjelvag (1981 a,b)* and *El-Shaer (1988)*.

B- Thermal time

Max. and Min. day and night temperature, daily range temperature as well as possible sunshine hours (PSSH) were recoreded in Figure (1).

The total day time mean temperature (TDT) night time mean temperature (TNT) and daily range temperature (TDRT) were calculated and discussed.

Daily range temperature = day time mean temperature night time mean temperature.

Photothermal units (PTU) were calculated. This parameter represents the product of the growing degree days (GDD), and day light hours by *(Bauer et al., 1984)*.

$$GDD=\sum_{j-1}^{n} \frac{T_{max.}+T_{min.}}{2} - Tb$$

W r ... and T max. and

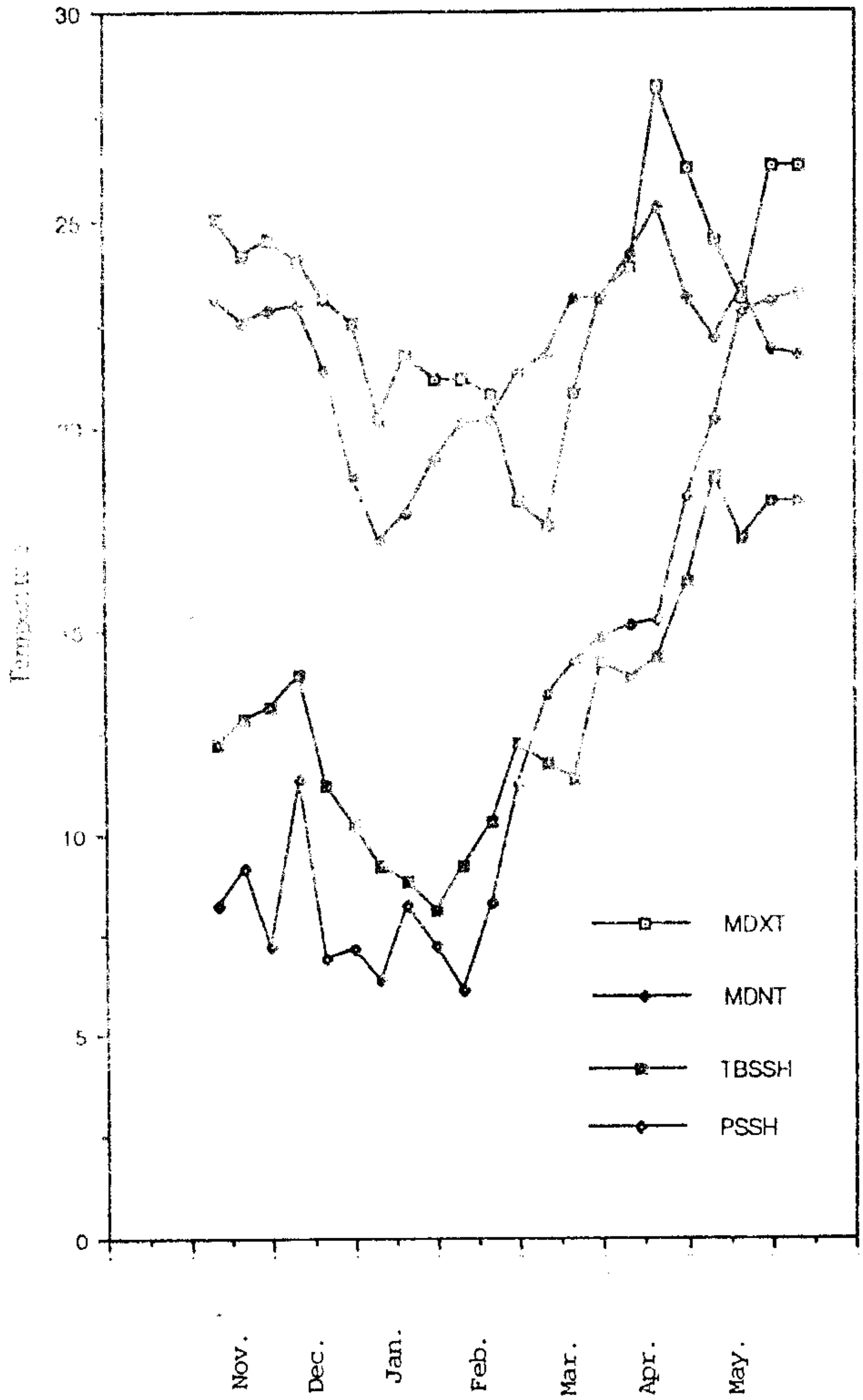

Fig. (1): Temperature in 1992-season at studied area.

T min.are daily maximum and minimum (hourly average temperature °C of day j, *El-Shaer et al.,(1988)* ,A Tb of 5 C, *Seeman and Lomes (1979)*.

$$PTU=\sum_{S_1}^{S_2} L\,(GDD)$$

where: L = day light hours, S_1 = begining of plant growth stage.and S_2 = end of plant growth stage.

Each period of phenological stage was assumed to require on equal thermal time (Cd) *El-Shaer (1988)*.

C- Heat Unit Efficiency (HUE)

Heat unit efficieny (HUE) = Total dry matter accumulation (DMA) divided by the growing degree days (GDD) according to *El-Shaer et al.,(1988)*.

These characters were measured as follows:

1-Total dry matter mg/plant after 45 days from sowing and every 10 days untill 105 days.

2-Straw yield as (Kg/fed.), seed yield as (Kg/fed.) and biological yield as (Kg/fedden).

D- Growth

Plant hight, number of branches and dry weight per plant were recorded after 45 days from sowing in 10 day-intervals up to 105 days from sowing.

E- Yield and its components:

Grain yield and its components were taken from the central 1 m^2 of each plot and converted into (Kg/fed.) adjusted at a moisture content of 15%. Five plant samples were taken and used for the following measurements.

Number of pods/plant, and seeds/pod, 100-seed weight, seed /plant (gm.), straw/plant (gm.), biological yield/m2 (kg.), seed yield /m2 (kg.), straw yield /m2 (Kg.), biological yield (ton/fed.), straw yield (ton/fed.), seed yield (ardab/fed.), seed protein percentage was determined according to (A.O.A.C. 1980) protein yield (Kg/fed.).

The efficieny of energy by units for producting seed, was determined by biological seed yield/feddan, straw yield/fed. and biological yield/fed. from sowing to physiological maturity as reported in ICARDA Annual Rep(1981).

Data were statistically analyzed according to Snedecor and Chochran (1967). Correlation analysis was made according to Sendecor (1956).

RESULTS AND DISCUSSION

A-Thermal time (Cd):

Thermal time measured in photothermal unit (PTU)., total day temperature (TDT) total night temperature (TNT) and total daily range temperature for some phenological stages of different *Pisum sativum* cultivars are presented in Fig. (2).

Results showed that all cultivars were significantly different in phenological stages except the stages from planting to emergence. The ranking of cultivars concerning the thermal time was similar to that when day summation was considered at all growth stages.

In this respect, Angus *et al.* (1981 a,b), Skjelvag (1981 a,b), Rady (1986) and El-Shaer (1988) found that the

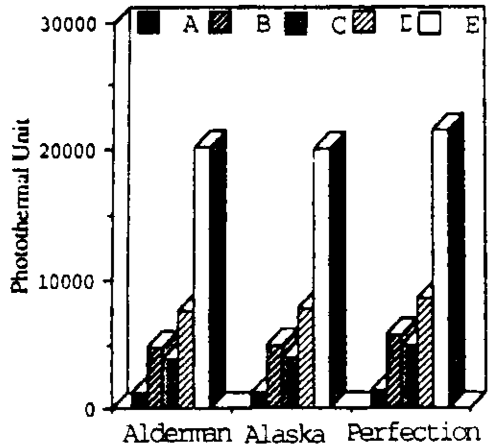

Fig. (2-A): Photothermal unit. (PTU).

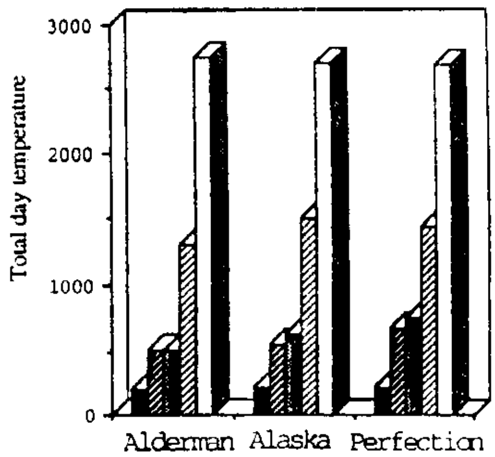

Fig. (2-B): Total day temperature (TDT).

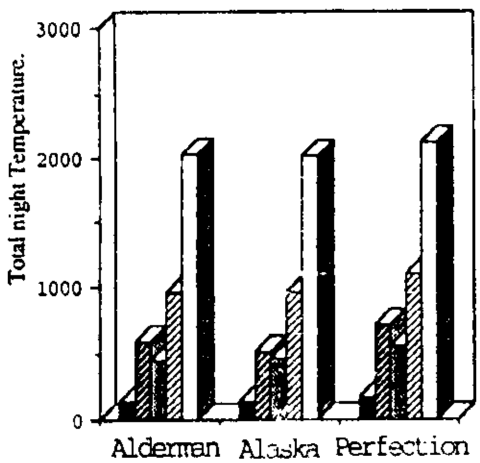

Fig. (2-C): Total nigh' temperature (TNT).

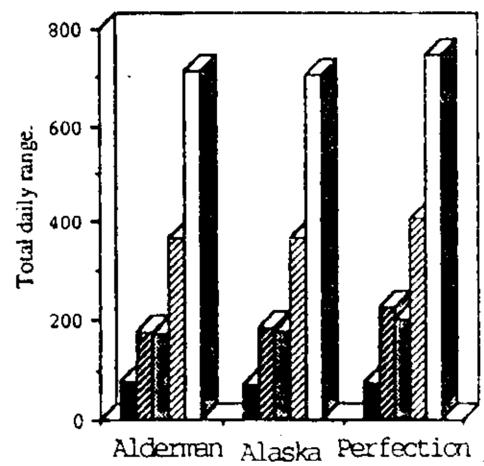

Fig. (2-D): Total daily range (TDR).

Fig (2): Ther-ıal time of different P. sativum cultivars in 1991/1992 season.

A ■ = Sowing to emergence.

B ▨ = Sowing to 1st flower.

C ■ = Emergence to 1st flower.

D ▨ = Sowing to 50% flowering.

E □ = Sowing to maturity.

physiological age at the phase change between the end of emergence to ripening may vary with thermal time (CD).

[illegible]

[illegible] stages.

[illegible] did not differ from each other in the period from sowing to emergence in 1992 season, (18.42 °C) at sowing period. Imam (1988) found that germination of seeds at 5 °C night temp. took 14 days until the first leaf was fully expanded, while germination of seeds at 20° C night temp. took eight days only. These results were found also by El-Shaer (1988), Rady (1986), Labudo (1987) and Ellis et al. (1988).

However, cultivars differed significantly in the length of vegetative growth period and consequently from planting to maturity. It is clear that the difference between the earliest

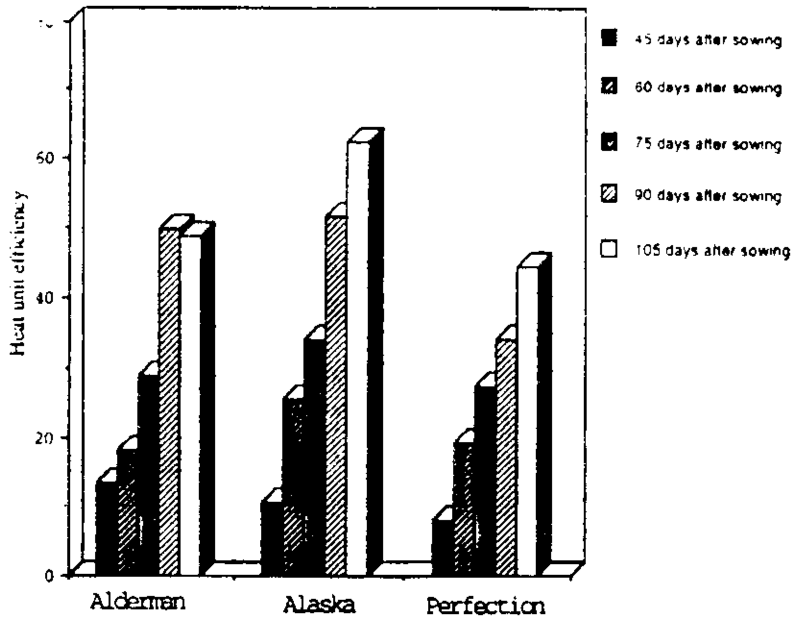

Fig. (3-A): Heat unit efficiency (HUE). for growth stages in three Pisum sativum cultivars in 1992-season.

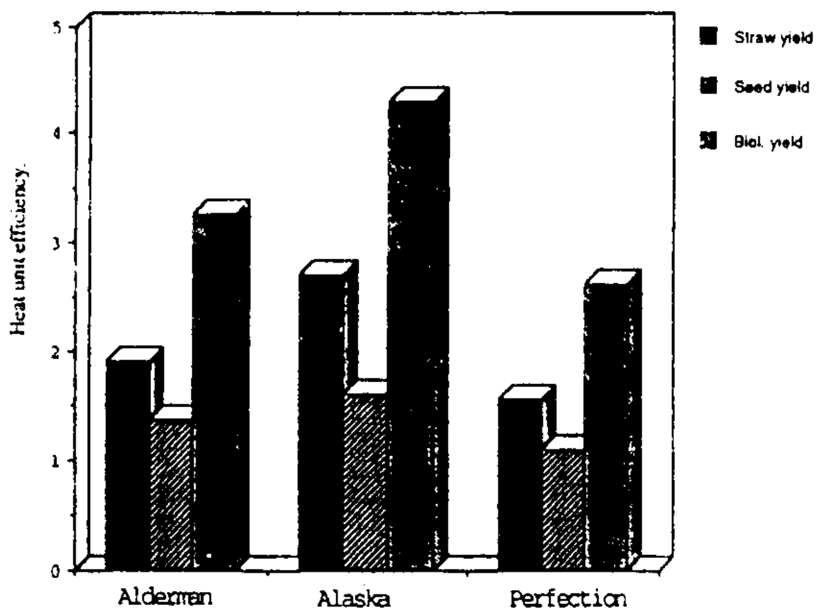

Fig. (3-B): Heat unit efficiency (HUE) in three Pisum sativum cultivars in 1992-season.

Fig. (3): Heat unit in three P. sativum cultivars in 1992 season.

variety (Alderman) and the latest one (Perfection) from sowing to 50% flowering was 8.9 days as an average of 1992 season.

As an average of 1992 season, day summation of vegetative growth stage (sowing 50% flowering) was about 55% from the day summation of planting to maturity, while summation during sowing to emergence and sowing to 1st flower was 6.% and 38.%, respectively.

The rates of phenological development were predominantly affected by day time temperature during all phases. The day from sowing to maturity decreased with rising temperatue. These ressults are in agreement with those obtained by Major (1980), Skjelvag (1981 a), El- Shaer (1988) and Rady (1986).

2- Growing degree days (GDD):

Results in Table (1), showed that cultivars differed significantly in GDD summation during most of the studied phenological stages, except from planting to emergence in 1992 season. El-Shaer (1988) and Rady (1986) found that Pisum sativum (Alaska) required GDD of 123- 135 from sowing to emergence.

The ranking of cultivars concerning temperature summation was similar to that when day summation was considered in Table (1).

In this respect Kaszuba (1987) and Skjelvage (1981 a), found that low temperature favoured vegetative growth, while high temperature favoured flower and seed production. El-Shaer (1988) and Rady (1986), found that physiological age at the phase change between the end of flowering and the beginning of ripening may vary with temperature levels.

3- Total bright sunshine hours (TBSSH) and potential sunshine

Table (1): Total number of days (TND) and total growing degree days (TGDD) for some phenological stages in <u>Pisum sativum</u> as influenced by variety durintg 1992 season.

Treatments	TND					TGDD				
	Sowing to Emerge.	Sowing to 1st flower	Emerge to 1st flower	Sowing to 50% flower	Sowing to matur.	Sowing to Emerge.	Sowing to 1st flower	Emerge to 1st flower	Sowing to 50% flower	Sowing to matur.
Variety:										
Alderman	10.00	49.80	39.80	81.30	156.90	129.88	507.18	377.30	793.50	186.60
Alaska	9.63	51.80	42.17	82.43	156.00	124.88	523.08	398.10	804.00	1847.61
Perfection	11.00	61.60	50.60	90.33	164.11	142.88	606.08	463.20	877.32	1998.12
L.S.D. (5%)	0.56	0.72	0.88	0.98	1.29	7.26	6.22	11.37	11.87	24.76

Table (2): Total bright sunshine hours (TBSSH) and total potential sunshine hours (PSSH) for some phenological stages in <u>Pisum sativum</u> as affected by variety in 1992 season.

Treatment	TBSSH					PSSH				
	Sowing to Emerge	Sowing to 1st flower	Emerge to 1st flower	Sowing to 50% flower	Sowing to matur.	Sowing to Emerge.	Sowing to 1st flower	Emerge to 1st flower	Sowing to 50% flower	Sowing to matur.
Variety:										
Alderman	47.40	368.60	292.20	611.50	1331.30	105.44	52.27	414.83	860.70	1777.90
Alaska	71.90	381.50	309.60	622.50	1321.80	101.54	541.57	440.03	870.60	1763.90
Perfection	82.30	440.90	366.60	698.40	1409.40	116.04	647.27	530.23	958.20	1872.70
L.S.D. (5%)	4.22	10.86	6.97	66.13	14.17	6.00	7.83	10.32	10.62	18.67

Table (3): The mean stem height and number of branches/ plant as influenced by variety in 1992 season.

	Stem height cm.					Number of branches/ plant				
	Days after sowing					Days after sowing				
Treatments	45	60	75	90	105	45	60	75	90	105
Variety:										
Alderman	56.13	77.59	85.39	87.61	88.88	1.63	1.73	1.93	1.93	2.12
Alaska	53.17	81.37	96.47	100.4	105.3	1.88	2.52	2.18	2.17	2.93
Perfection	28.62	38.09	53.67	76.83	79.58	2.83	2.72	3.33	2.93	3.68
L.S.D. (5%)	2.44	4.32	4.81	6.89	7.15	0.57	0.63	0.57	0.60	1.05

hours (PSSH)

Results in Table (2) showed that all Pisum sativum cultivars differed significantly in phenological stages, except the potenial sunshine hours (PSSH) in the emergence period. Generally, total day sum from sowing to maturity for late maturing cultivars was more difficult to determine than early ones. The longer time for all growth stages of the late ones was most likely caused by slower accumulation of energy indices during the season, Major (1980).

Debace et al. (1985) found that environmental factors such as light intensity and temperature can affect the number of open flowers. The number of new flowers opening poaked between 1500 and 1700 h. These results are in agreement with those obtained by Shalaby and Mohamed (1978), Ibrahim (1981) and Hegazi et al. (1984).

Generally, it should be mentioned here that energy indices or microclimatic factors play an important part in controlling Pisum sativum plant growth and development throughout the season.

D- Growth

Average stem height, number of branches per plant and total plant dry weight of the three Pisum sativum cultivars under the two plant populations (22.22 plants/m2 and 33.33 plants/m2) in different plant ages are presented in Table 3 and 4.

Results indicate that average plant height increased gradually after 45 days from sowing to reach its maximum at 105 days from sowing date in all cultivars. The highest plant

Delta J. Sci. 17 (1) 1993

Table (4): The mean dry matter g/plant of Pisum sativum as influenced by variety in 1992 season.

	Days after sowing				
Treatments	45	60	75	90	105
Variety:					
Alderman	7.69	12.97	21.98	24.89	30.99
Alaska	10.79	21.71	28.56	29.67	36.28
Perfection	6.45	10.37	15.23	26.55	31.44
L.S.D. (5%)	1.60	2.25	4.14	2.12	1.94

Table (5): The mean values of yield componenets in Pisum sativum as influenced by variety in 1992 season.

Treatments	Number of pods /plant	Number of seeds /pod	100-seed weight (gm)	Seed yield/ plant (gm)	Straw yield/ plant (gm)	Seed yield/ m2 (kg)	Stram yield/ m2 (kg)
Variety:							
Alderman	21.88	3.63	69.13	27.25	45.88	0.749	1.256
Alaska	25.13	4.00	70.63	33.75	50.13	0.926	1.377
Perfection	9.00	4.62	100.88	19.63	38.25	0.551	1.048
L.S.D. (5%)	2.90	0.58	1.25	2.36	2.92	0.060	0.075

Table (6): The mean values of Pisum sativum yield and protein content of seeds as influenced by variety in 1992 season.

Treatments	Seed yield/ faddn (Ardab)	Straw yield/ faddan (Ton)	Biological/ yield/ faddan (Ton)	Protein content %	Protein yield/ faddan (Kg)
Variety:					
Alderman	21.00	5.28	8.43	16.07	506.21
Alaska	25.09	5.79	9.68	17.13	665.50
Perfection	15.40	4.41	6.72	13.71	316.7
L.S.D. (5%)	1.68	0.32	0.57	0.325	41.0

Table (7): Pisum sativum seed yield, straw and biological yield in kg./energy unit as affected by variety in 1992 season.

	Seed yield (Kg)				Straw yield (kg)				Biological yield (Kg)			
Variety	Per Day	Per GDD	Per TBSSH	Per PSSH	Per Day	Per GDD	Per TBSSH	Per PSSH	Per Day	Per GDD	Per TBSSH	Per PSSH
Aldeerman	20.05	1.96	2.36	1.77	33.62	2.83	3.96	2.97	53.80	4.52	6.34	4.75
Alaska	24.93	2.11	2.94	2.20	37.07	3.13	4.38	3.28	61.92	5.24	7.31	5.48
Perfection	4.11	1.16	1.64	1.24	6.24	2.20	3.12	2.35	40.98	3.36	4.77	3..59

elongation was found between 45 and 60 day-old in Alaska and Alderman; 60 and 75 day-old in Perfection. This could be attributed to delayed flowering in Perfetion than in Alaska and Alderman. It is clear that Alaska was superior in plant height than Alderman or Perfection. As to the number of branches per plant, it is clear from Table 3 that Perfection gave greater number of branches per plant in both seasons.

Results in Table 4 indicate that average plant dry weight increased gradually by the increase in the plant age in all varieties. Alaska gave higher total plant dry weight than Alderman and Perfection.

E- Yield and yield components:

Data in Table 5 and 6 show that *Pisum sativum* cultivars differef significantly ($P<0.05$) in the studied character, Alaska cultivars was superior to the other cultivars in all studied traits, eccept number of seeds/pod and 100-seed weight (Table 5). Similar results were reported by Salem and El-Massri (1986). However, the highest No. of seeds/pod and 100-seed weight were obtained from Perfection cv.

The number of pods per plant as an important contributor to yield tended to be high in Alaska than in of Alderman or Perfection. It is evident that individual plant is the product of its genotype and environment. Considering the environment, there are min., optim. and max. environmental conditions for the plant. The increase per plant and per square meter could be attributed directly to increasing the number of branches per plant (Table 3), total dry weight (Table 4), flowering and pod formation period (Table 1). These results indicate that

Alaska was more efficient in producing seeds, straw and biological yield/day, per GDD, TBSSH and PSSH than Perfection (Table 7), similar results for the effect of microclimatic [illegible] seed and straw yield were reported by Ragab [illegible] [illegible] and Abd [illegible] [illegible] which they are grown.

This study emphasizes the importance of [illegible]

A general recommendation to [illegible] concentrate on total dry matter increase per plant or per unit area. Dry matter can be used for selection of high yielding genotypes. Improvement of environmental conditions and enhancement of field management can also enable the total dry matter to reach a desirable level, i.e. markedly increase the yield.

Stronge and significant negative correlations (Table 8) were found between No. of pods/plant, No. of seeds/plant, 100-seed weight, biological yield/m^2, seed yield/m^2 , biological yield ton/fed., seed yield ard./fed. protein yield/fed. and NDTM, TGDD, TBSSH and PSSH.

Delta J. Sci. 17 (1) 1993

Table (8): Correlation coefficient value (r) for the association between NDTM, TGDD, TBSSH and PSSH and som yield components of Pisum sativum in 1992 season

	Energy indices			
Yield Components	NDTN	TGDD	TBSSH	PSSH
Pod number/ plant	-0.876*	-0.879*	-0.877*	-0.672*
Seed number/plant	-0.893*	-0.895*	-0.895*	-0.889*
100- seed weight	-0.945	-0.948	-0.946	-0.937
Seed yield/plant	-0.786	-0.033	-0.766	-0.784
Straw Yield/plant	-0.652	-0.655	-0.653	-0.648
Biological yield/m^2	-0.854*	-0.841*	-0.844*	-0.853*
Seed yield/ m^2	-0.883*	-0.879*	-0.681*	-0.891*
Straw yield/m^2	-0.801	-0.798	-0.800	-0.810
Biological yield/fad.	-0.845*	-0.843*	-0.845*	-0.855*
Straw yield /faddan	-0.802	-0.789	-0.801	-0.811
Seed yield/ faddan	-0.882	-0.878	-0.880	-0.890
Protein yield/ faddan	-0.885	-0.834	-0.884	-0.890

* = Significant at 5%

A similar finding was reported by Skjelvag (1981 a) who found that house of bright sunshine significantly affected seed yield, related with GDD in five years.

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تأثير درجة الحرارة على الأطوار الفينولوجية والنمو والمحصول لنبات البسلة

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تعتبر دراجات الحرارة من أهم العوامل البيئية الموثرة فى محصول البسلة وأمكن تقسيم الواحدات الحرارية المدروسة الى :

* الوحدات الحرارية الضوئية
* مجموع درجات حرارة النهار
* مجموع درجات حرارة الليل
* الفرق بين درجات حرارة الليل والنهار ٠

كما أستهدف البحث تجميع أسس الطاقة وتشمل (عدد الأيام- الحرارة المتجمعة - الشمس الفعلية والشمس الممكنة) وذلك فى ثلاثة أصناف من البسلة وهى الالدرمان والآلسكا والبيرفكشن ٠

وقد كانت النتائج كما يلى :

يحتاج نبات البسلة الى

الوحدات الحرارية الضوئية	١٣٣٧	٥٤٩٥	٤١٥٧	٨٣٣٧	٢١٠٨٦
مجموع درجات حرارة النهار	٢٠٥	٨٩٠	٦٨٤	١٣٧٧	٢٨١٩
مجموع درجات حرارة الليل	١٤٩	٦٧٤	٥٧٤	١٠٣٢	٢١٢١
الفرق بين حرارة الليل والنهار	٦٠	٢٢٧	١٦٦	٣٥٤	٧١٣

فى الأطوار الفينولوجية من الزراعة الى تكشف البادرات من الزراعة لأول زهرة -ومن الزراعة الى منتصف التزهير - ومن الزراعة الى النضج الفسيولوجى على التوالى ٠

كانت العلاقة بين الوحدات الحرارية والمادة الجافة معنوية خلال مراحل

النمو من ٤٥ الى ١٠٥ يوم من الزراعة مع الحبوب والمحصول البيولوجي.
إختلفت الأصناف فيما بينهما فى بعض مراحل النمو المدروسة وقد لوحظ نفس الإتجاه بالنسبة لعوامل الطاقة المتجمعة للأطوار الفينولوجية من الزراعة حتى النضج وعلى ذلك تدل النتائج أنه يمكن إستخدام الحرارة المتجمعة لتوقع طول المراحل الفينولوجية من خلال سجلات درجات الحرارة مقدما وبالتالى يمكن توقع موعد النضج والحصاد لصنف ما.
يحتاج نبات البسلة الى ١١٧, ٥٦٦ , ٧٨٨, ١٧٩٨ حرارة متجمعة , ٨٢ ,٤٢٩, ٦٤٥, ٥, ١٣١٤ شمس فعلية , ١٤ , ٦٢٩ , ٩٢٥ , ١٨٥٦ , شمس ممكنة من الزراعة الى الإنبات - من الزراعة الى أول زهرة - من الزراعة الى منتصف التزهير - ومن الزراعة الى النضج الفسيولوجى على التوالى.
اختلفت الأصناف معنويا فى محصول البذور ومكوناته وقد تفوق الصنف آلسكا عن باقى الأصناف فى زيادة المحصول بوحدة المساحة بينما تفوق الصنف بيرفكشن فى وزن ١٠٠٠ بذرة وعدد بذور القرن عن باقى الأصناف.
ظهرت من دراسة الإرتباط أن هناك إرتباط معنوى سالب بين أسس الطاقة المدروسة والمحصول ومكوناتة