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EFFECT OF SOWING DATES AND GENOTYPES ON THE YIELD OF CORIANDER (*Coriandrum sativum* L.)

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Abstract

A field experiment on coriander (*Coriandrum sativum* L.) taking five sowing dates viz. November 01, November 16, December 01, December 16 and December 31 and four selected genotypes viz. CS001, CS007, CS008 and CS011 was conducted during the Winter season of 2009-10 at Bangabandhu Sheikh Mujibur Rahman Agricultural University to study heat efficiency for the crop. The crop sown on November 16 and the genotype CS011 showed the highest heat use efficiency for dry matter, seed and stover yield. Heat use efficiency for dry matter as well as seed yield increased from November 01 to November 16 and then decreased with delayed sowing. November 16 sowing coupled with CS011 gave the maximum heat use efficiency for seed yield. Growing Degree Days (GDD) showed a positive linear response with dry matter accumulation and coefficient of regression was high in November 16 sowing as well as in CS011. Heat use efficiency showed a negative linear response with maximum (y = 2.058 – 0.054, R^2 = 0.682*), minimum (y = 2.123 – 0.070x, R^2 = 0.687*) and mean (y = 2.13 – o.063x, R^2 =0.709*) temperature but positive linear response with relative humidity (y = 0.074x – 5.593, R^2 = 0.702*).

Keywords: Heat use efficiency (HUE), Growing Degree Days, Coriander Genotypes, Dry matter and Sowing Dates

Introduction

Coriander (*Coriadrum sativum* L.) belonging to the family Apiaceae is a spice crop cultivated during winter season in Bangladesh. The coriander is cultivated for both the fresh green herb and the spice seed. Its fresh twigs, leaves and seeds are well known to need any introduction or discipline particularly to the housewife. Particularly all parts of the plant are used as spices and condiments which have pleasant aroma (Shanmugavelu *et al*., 2002).

Crop production mainly depends upon the climatic requirement of a particular crop. Temperature is a very important climatic factor which affects plant growth, development and yield. Temperature also plays a key role in determining sowing

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time (Tiwari and Singh, 1993). Winter crops are vulnerable to high temperature during reproductive stages (Kalra, 2008). Each phenophase of a particular crop has an optimum temperature for its initiation and development and changes in this optimum temperature affects the yield of a crop mainly through changes in phenological processes by influencing plant physiological processes including photosynthesis and respiration (Sharma *et al*., 2003). Coriander is a temperature sensitive crop. Its optimum temperature for germination and early growth is 20-25^{o}C (Singhania *et al*., 2006). Relatively cool weather during vegetative period and warm weather during reproductive stage are ideal for coriander crop (Tiwari *et al*., 2002). The optimum sowing time of coriander in Bangladesh is November 15. The life cycle of the coriander plants become shorter as the sowing is delayed that adversely affects yield of coriander (Ahmed and Haque, 1985). Plants in delayed sowing face adverse climate during vegetative and reproductive stages. In delayed sowing plants do not get optimum temperature during vegetative and reproductive growth in coriander and ultimately seed yield decreases. Heat unit requirement or growing degree day (GDD) has been used for characterizing the thermal response in different winter crops (Rajput *et al.*, 1987; Shanker *et al*., 1996). The quantification of heat use efficiency (HUE) is useful for the assessment of yield potential of a crop in different growing environments (Pal and Murty, 2010). Higher the HUE, higher the yield of wheat (Hussain *et al*., 2010) ; Pal and Murty, 2010) and rice (Islam and Sikder, 2011). The experiment was, therefore, undertaken to observe the heat use efficiency of coriander genotypes under different sowing dates.

Materials and Method

The experiment was conducted to determine the effect of sowing dates and genotypes on the yield of coriander during the winter season of 2009-10 at the research farm of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. The experiment was laid out in split-plot design having five sowing dates viz. November 01, November 16, December 01, December 16 and December 31 in the main plots and four genotypes viz. CS001, CS007, CS008 and CS011 in the subplots. The unit plot size was 4.8 m^2 (4 m ×1.2 m.). The crop was fertilized @ cowdung 5 t/ha and 80-40-20-20 kg/ha of N-P-K-S. The entire amount of cowdung, phosphorus from TSP, potassium from MP, sulphur from gypsum with one- half of nitrogen as urea were applied during final land preparation. The rest of the nitrogen was topdressed in two equal splits at 30 and 60 days after sowing. The sowing of each genotype was done according to selected sowing dates. Slight watering was done just to supply sufficient moisture needed for quick germination. A recommended agronomic production package was followed for the crop (Razzak *et al*., 2004). Seeds were harvested when half of the green seeds on the plant changed to brown colour as suggested by Singhania *et al.* (2006).

Yield data were collected from the inner rows of each plot to avoid the border effect. In each unit plot 10 plants were selected randomly for recording data on yield components and yield. The data were recorded on seed yield/plant, stover yield (kg), dry matter/m^2 and harvest index (%). For recording drymatter (DM) accumulation over time, 10 plants were harvested at random from 25 days after sowing to maturity (119 days) at 15- day intervals. The crops which recorded less than 119 days for harvest are kept in the field up to 119 days. The plant samples were oven dried at 72^{o}C for 72 hours and weight was taken by electric balance. Dry weights were converted to per m^2 for calculating DM.

Heat Unit/Growing Degree Day (GDD)

Growing degree day (GDD) or heat unit were calculated as per the equation suggested by Iwata (1984) :

$$GDD = \sum\{(T_{max} + T_{min}) - Tb\}$$

Where T_{max} is the maximum temperature (^{o}C),

T_{min} is minimum temperatur (^{o}C),

T_b is the base temperature taken as 4.8^{o}C (Hrnander Devi *et al*., 2002).

The daily maximum and minimum temperature were recorded in Weather Station, Dept. Agricultural Engineering, BSMRAU, Salna, Gazipur situated 100 m away from the field. The heat use efficiency (HUE) for dry matter was calculated by the method suggested by (Sharma *et al.*, 2003) and for seed yield by (Pal and Murty, 2010);

$$HUE = \frac{DM}{\sum HU} \text{ g/m}^2\text{/deg. day)}$$

$$HUE = \frac{Seed\ yield\ (kg/ha)}{\sum HU} \text{ kg seed/ha/deg. day)}$$

Where, DM is dry matter (g/m^2), $\sum$ HU is the cumulative heat unit (^{o}C day).

Correlation and regression analyses were done to study the relationship between GDD (HU) and dry matter, and HUE and weather elements. The data were compiled properly and analyzed statistically by MSTAT Program and mean comparison was done following the Duncan's Multiple Range Test at 5% level of probability.

Table 1. Mean air temperature (^oC) during sowing to emergence and 50% flowering to seed- filling stage.

Sowing time	Sowing to emergence			50 % flowering to seed filling stage		
	Max.	Min.	Mean	Max.	Min.	Mean
Nov. 01	28.13	24.77	26.45	21.36	16.82	19.09
Nov. 16	25.45	17.85	21.65	22.19	17.87	20.03
Dec. 01	25.15	17.38	21.27	28.17	23.82	26.00
Dec. 16	20.40	15.60	18.00	26.50	21.75	24.13
Dec. 31	20.70	16.11	18.41	28.05	24.13	26.31

Results and Discussion

The heat use efficiency (HUE) increased with growing period and attained the maximum at seed filling stage in all treatments (Table 2). The maximum HUE was recorded from the crops sown on November 16 followed by December 01 in all phenological stages and its minimal value was recorded from December 31 sown crops. HUE at each phenophase increased from November 01 to November 16 and then decreased with delayed sowing. Mean value of HUE was also the maximum in November 16 sown crop and then decreased with delay in sowing of crop. Similar results were reported by Sharma *et al*. (2003) in wheat crop and Kumar *et al*. (2008) in soybean crop. The genotype CS011 gave the highest HUE in all phenological stages followed by CS001 and CS007 (Table 2). Mean value also revealed that CS011 had the highest HUE followed by CS001, CS007 and CS008.

Table 2. Heat use efficiency (HUE) (g/m^2/deg day) of coriander as influenced by different sowing dates and genotypes at different phenological stages.

Treatment	Phenological stages				
	Branching	50% flowering	Seed filling	Maturity	Mean
Sowing date					
November 01	0.031	0.46 c	0.68 c	0.64 c	0.452 c
November 16	0.036	0.54 a	0.76 a	0.71 a	0.511 a
December 01	0.034	0.50 b	0.72 b	0.67 b	0.481 b
December 16	0.032	0.49 b	0.71 b	0.67 b	0.475 b
December 31	0.029	0.44 d	0.62d	0.59d	0.420 d
Genotype					
CS001	0.032	0.50 b	0.70 b	0.69 b	0.48 b
CS007	0.033	0.48 b	0.65 c	0.62 c	0.45 c
CS008	0.030	0.44 c	0.60 d	0.58 d	0.41 d
CS011	0.039	0.55 a	0.76 a	0.73 a	0.52 a
CV (%)	Ns	3.67	3.62	4.21	3.84

Means showing similar letter (s) in a column are not significant at 5% level by DMRT.

Growing Degree day (GDD) values at harvest were little influenced by sowing dates (Table 3). Higher GDD at harvest was recorded with November 01 sowing (1938 °C day) followed by December 31 sowing (1922 °C day) and November 16 sowing (1902 °C day) while GDD was the lowest in December 16 sowing (1816 °C day). Around 2000 °C GDD is optimum for coriander seed production suggested by Carrubba *et al.* (2006).

Higher GDD in November 01 sowing was probably due to the crops subjected to low temperature resulted in long maturity duration (119 days). Although the crops of November 16 sowing matured at 118 days after sowing, it had 36 GDDs less than November 01 sowing because at early growth stage the crops faced somewhat lower temperature which was optimum for early growth. The crop sown on December 31 required 1922 GDDs, which might be due to higher temperature during reproductive stage (Table 1) although maturity duration was only 104 days. The lowest GDDs in December 16 were probably due to medium low temperature during reproductive stage and 107 days of maturity. It was clear that GDD decreased with the advancement of sowings except December 31 sowing. This is in close conformity with the report of Pal and Murty (2010) in wheat. The genotype CS001 had the highest GDDs (2023) followed by CS011 (1873), CS007 (1846) and CS008 (1834) (Table 3). There was no significant difference among CS011, CS007 and CS008 with regard to GDD. The variation in GDDs in different genotypes might be due to variation in maturity days of the genotypes. Heat use efficiency was low in CS001 for higher GDD and less seed yield.

Table 3. Growing Degree days (GDDs), seed yield, stover yield and heat use efficiency (HUE) as influenced by sowing dates and genotypes.

Treatment	GDD at harvest (°C day)	Seed yield (t/ha)	HUE (kg seed /deg. day)	Stover yield (t/ha)	HUE (kg stover /deg. day)
Sowing date					
Nov. 01	1938 a	1.62 c	0.84 b	2.00 ab	1.03 b
Nov. 16	1902 a	1.81 a	0.95 a	2.07 a	1.09 a
Dec. 01	1893 ab	1.71 b	0.90 a	1.96 bc	1.03 b
Dec. 16	1816 b	1.57 d	0.85 b	1.91 cd	1.05 b
Dec. 31	1922 a	1.44 e	0.75 c	1.85 d	0.96 c
Genotype					
CS001	2023 a	1.55 c	0.77 c	2.42 a	1.20 a
CS007	1846 b	1.64 b	0.89 b	1.75 c	0.95 c
CS008	1834 b	1.42 d	0.77 c	1.61 d	0.88 d
CS011	1873 b	1.91 a	1.02 a	2.05 b	1.10 b
CV (%)	4.4	4.12	4.67	3.94	4.01

Means showing similar letter (s) in a column are not significant at 5% level by DMRT.

The highest seed yield was obtained from November 16 sowing (1.81 t/ha) which was followed by December 01 sowing (1.71 t/ha) while the lowest in December 31 (Table 3). This is in agreement with the findings of Ahmed and Haque (1985) and Toncer *et al.* (1998). Seed yield was consistently the highest (2.02, 1.19 and 1.65 t/ha in the 3 years, respectively) after sowing on 25 October in Sudan where average air temperature was close to 25^{o}C in last week of October reported by Mohamed (1992). The temperature of 25^{o}C was optimum for coriander growth that was close to November 16 sowing (25.45^{o}C, Table 1). The November 16 sown gave the highest yield because the crops enjoyed more or less suitable temperature during both vegetative stage and reproductive stage (Table 1). The lower yield was recorded from December 16 sowing followed by December 31 sowing. This happened probably due to very low temperature during early vegetative growth and high temperature above optimum during flowering and fruit setting stage (Table 1) and shorter growing seasons. The lower yield in November 01 sowing compared to November 16 and December 01 sowing could be due to the fact that high temperature as well as low temperature was during vegetative growth and flowering and fruit setting phase, respectively (Table 1). The yield of crop increased from November 01 sowing to November 16 sowing and then decreased gradually. Ahmed and Haque (1985) also reported delayed sowings decreased the seed yield of coriander.

The November 16 sown crop exhibited the maximum HUE of 0.95 kg seed/ha/deg. day closely followed by December 01 sown crop (0.90 kg seed/ha/deg. day) while the December 31(very late) sowing had the lowest HUE (Table 3). From November 16 sowing HUE was found to be decreased with late sowing. Similar results were reported by Pal and Murty (2010) in wheat. The genotype CS011 showed the highest HUE (1.02 kg seed/ha/deg. day) which was followed by CS007 while the genotypes CS001 and CS008 showed the lowest HUE. Heat use efficiency of 0.98-1.51 kg grain/ha/deg. day in fine rice was reported by Islam and Sikder (2011). The maximum HUE of 2.93 kg grain/ha deg. days in wheat was also reported by Pal and Murty (2010).

Dry matter was influenced by cumulative heat unit i.e., growing degree day (GDD) in all the sowings as shown in (Table 4). It was observed that dry matter was directly and linearly associated with cumulative heat units. The correlation between GDD and genotypes were highly significant. The R^2 values ranged from 0.75 to 0.95 which were significant at $p \leq 0.01$. The b values i.e., coefficient of regression ranged from 0.532 to 0.836 which were highly significant at $p \leq 0.01$. The value of slope of regression (b) was the maximum in November 16 sowing. The slope of regression (b) was significantly higher in November 16 sowing as compared to December 16 and December 31 sowings and the slopes of November 16, November 01 and December 16 sowings was at statistically similar level. This shows that the coriander crop sown on November 16 is more efficient in heat utilization as compared to November 01, December 16 and December 31 sowing. Dry matter for genotype was also positively related with cumulative heat unit i.e., growing degree day (GDD) in all genotypes as shown in (Table 4.). Dry matter was directly and linearly associated with cumulative heat units. The correlation between GDD and genotypes were highly significant. The R^2 values ranged from 0.78 to 0.79 which were significant at $p \leq 0.01$.The coefficient of regression ranged from 0.464 to 0.616 which was significant at $p \leq 0.01$. The value of coefficient of regression was maximum in CS011 (0.616) as compared to other genotypes. The slope of regression (b) was significantly higher in CS011 as compared to CS001, CS007 and CS008. The slope of regression line developed for each genotype showed that CS011 was more efficient in heat utilization in comparison to other genotypes.

Table 4. Response equations to the fitted GDD and dry matter produced at different sowing date and by genotypes

Treatment	Regression equation	Coefficient of regression (b value)	R^2 value	Coefficient of correlation (r)
Sowing date				
November 01	y = - 602.58 + 0.833x	0.833** ± 0.135	0.88**	0.94**
November 15	y = - 608.42 + 0.836x	0.836** ± 0.085	0.75**	0.87**
December 01	y = - 449.26 + 0.766x	0.766 **± 0.093	0.93**	0.96**
December 16	y = - 359.78 + 0.648x	0.648** ± 0.078	0.93**	0.96**
December 31	y = - 328.47 + 0.532x	0.532** ± 0.050	0.95**	0.97**
Genotype				
CS001	y = - 216.66 + 0.589x	0.589** ± 0.05	0.78**	0.88**
CS007	y = - 196.03 + 0.544x	0.544** ± 0.07	0.79**	0.89**
CS008	y = - 160.58 + 0.464x	0.464** ± 0.065	0.79**	0.89**
CS011	y = - 216.66 + 0.616x	0.616** ± 0.08	0.79**	0.89**

** indicates significant at the 1% level, ± SE (standard error).

The highest stover yield was recorded from November 16 sowing closely followed by November 01 sowing and the lowest value, from December 31 sowing (Table 3). The genotype CS001 produced the maximum stover yield (2.42 t/ha) followed by CS011 (2.05 t/ha) and the lowest from CS008. The maximum HUE for stover was noticed in November 16 sowing followed by December 01, November 01 and December 16 sowing and the lowest HUE from December 31 sowing (Table 3). The maximum HUE for stover was recorded from CS001 followed by CS011. The highest HUE for stover was recorded in soybean (Kumar *et al.*, 2006).

The highest yielding genotype was CS011 when sown on November 16 (2.05 t/ha) or December 01 (2.02 t/ha) (Table 5). The lowest yielding genotype was CS008 at December 16 and December 31 sowings. The genotype CS011 produced consistently higher seed yield than CS007 irrespective of sowing dates. The genotype CS007 also produced consistently higher seed yield than CS001 across sowing dates, although there was no difference in seed yield between the two genotypes at December 01 sowing. Lower seed yields were recorded in all genotypes at late sowings (December 16 and December 31) as compared to other sowings. Reduction in yield components and thereby seed yield at late sowings were due to short growing period, lower temperature in vegetative growth stage and higher temperature at reproductive phase (flowering, fruit setting and seed filling stage) (Table 1**).**

Table 5. Seed yield (t/ha) of coriander as influenced by interaction of genotype and sowing date

Sowing date \ Genotype	CS001	CS007	CS008	CS011
November 01	1.52 g	1.63 f	1.41 hi	1.91 b
November 16	1.76 de	1.81 cd	1.62 f	2.05 a
December 01	1.63 f	1.68 ef	1.51 g	2.02 a
December 16	1.47 gh	1.63 f	1.33 ij	1.86 bc
December 31	1.35 i	1.46 gh	1.25 j	1.70 ef
CV (%)		4.12%		

Means showing similar letter (s) are not significant at 5% level by DMRT.

Table 6. Heat use efficiency of coriander genotypes for seed yield under different sowing dates (kg seed/ha/deg day),

Sowing date \ Genotype	CS001	CS007	CS008	CS011
November 01	0.77 ef	0.86 cd	0.75 f	1.00 b
November 16	0.90 c	0.97 b	0.87 cd	1.09 a
December 01	0.83 d	0.90 c	0.81 de	1.07 a
December 16	0.77 ef	0.89 c	0.73 fg	1.00 b
December 31	0.68 gh	0.77 ef	0.67 h	0.90 c
CV(%)		4.67		

Means showing similar letter (s) are not significant at 5% level by DMRT.

Among the five sowing dates, the crops sown on November 16 gave the highest HUE irrespective of genotypes (Table 6). The November 16 sown crops exhibited the maximum HUE (1.09 kg seed/ha/deg. days) for the genotype CS11 closely followed by December 01 sowing (1.07 kg seed/ha/deg. days) for the same genotype (Table 6).There was no significant difference between December 01 sowing and November 01 sowing irrespective of genotypes with regard to heat use efficiency. The December 31 sown crop gave the minimal HUE irrespective of genotypes.

Heat use efficiency of coriander showed a negative linear response with the maximum, minimum and mean temperature, while it showed a positive linear response with relative humidity (Fig.1). R^2 values for weather parameters ranged from 0.682 to 0.709 which were significant at $p \leq 0.05$. In wheat crop, similar results for temperature were obtained by Sharma *et al.* (2003) but they reported a parabolic response with relative humidity. The response equations obtained between heat use efficiency and weather elements can be used for simulating the response of heat use efficiency of coriander crops with parameters.

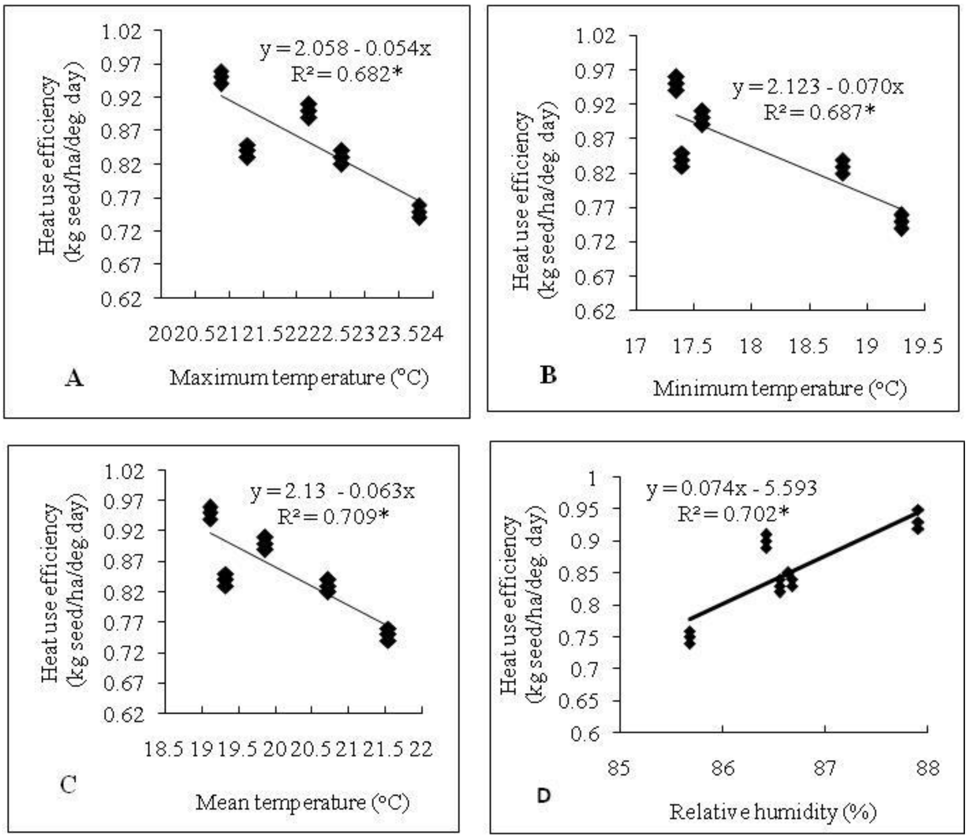

Fig. 1. Relationship between heat use efficiency and weather parameter in coriander crop.

Conclusion

It is, therefore, concluded that sowing of coriander crop on November 16 exhibited higher heat use efficiency for dry matter, seed yield and stover yield. November 16 sowing found the maximum seed yield. Coriander crop sown on November 16 and the genotype CS011 are more efficient in heat utilization. The given agro-climatic conditions of Salna areas (AEZ-28) was found to be beneficial for the coriander crop sown for good harvest. The crop would become suitable for harvest after receiving a thermal sum of 1902 GDD (°C).

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