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Temporal Effects on Gas Exchange Characteristics of Blackgram

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Abstract: Pot experiment was conducted to asses the temporal effects on gas exchange characteristics of blackgram at different growth stages. Two blackgram varieties namely BARImash 3 and BINAmash 1 were sown at 10 days interval on August 26, September 6, September 16 and September 26 of 1999. At each sowing time, photosynthetic gas exchange characteristics were measured at vegetative, flowering, pod filling, early maturity, mid maturity and late maturity stages of blackgram. Varietal difference was minimal but sowing time had profound effects on gas exchange characteristics of blackgram. Photosynthetic rate was higher in blackgram leaf sown on August 26 with its higher stomatal conductance, lower intercellular CO_2 concentration and higher mesophyll conductance. The highest respiration rate was recorded at pod filling stage and fluctuated widely over the sowing times. Photosynthetic rate of blackgram decreased with delay in sowing times and the lowest rate was observed on September 26 sowing. Gas exchange characteristics were the highest at flowering stage of blackgram and declined gradually with the advent of plant age.

Key words: Temporal effects, photosynthesis, blackgram

Introduction

Growth and yield of crops depend on many physiological processes operating in plant systems photosynthesis and its associated other characteristics are the center of all physiological processes of plants. Photosynthesis alone contributes about 90% of total dry matter production in plants. A plant therefore, must possess an efficient photosynthetic mechanism for better productivity. Photosynthetic process of plants varies over the wide range of genetic and environmental factors. Variation in photosynthesis among the species and within the species have been reported (Dornhoff and Shibles, 1970; Hesketh *et al.*, 1981). Among the environmental factors light and temperature are important factors in regulating the photosynthesis in plants. Light is considered as the driving force of photosynthesis which depends on the leaf area development and the amount of light intercepted by the canopy. Temperature affects the physiological efficiency of leaves during photosynthesis of crop plants.
The availability of incident light and proportion that is intercepted by the crop changes with the shifting of sowing time in the growing season. Shifting of sowing times is more profound in case of crops grown in rainfed condition. Variation in sowing times modifies radiative and thermal conditions of crops during growth periods and effects on leaf number, canopy development, interception of incident radiation and eventually on its gas exchange characteristics (Cirilo and Andrade, 1994; Warington and Kanemasu, 1983). Therefore, it is worthfull to know the gas exchange characteristics of crops exposed to different growing environments by altering the sowing times. However, the effects of sowing time on the gas exchange characteristics of blackgram over the sowing times and growth stages are almost lacking. The present study was undertaken to observe temporal effects on gas exchange characteristics at different growth stages of blackgram.

Materials and Methods

Pot experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, Bangladesh during summer season of 1999. Soil of the pot was prepared by mixing silty loam soil and well-decomposed cowdung in 3:1 ratio. One thin layer of broken bricks was placed on the bottom of the pot for easy drainage of excess water. Prior to seeding a fertilizer dose of 20- 60 - 40 kg N, P, K ha^{-1} was applied as basal dose. Another 20 kg N ha^{-1} was used as top dress at vegetative stage of blackgram. Two blackgram varieties were selected for the experiment, one was BARImash 3 released by the Bangladesh Agricultural Research Institute (BARI) and another was BINAmash 1 released by the Bangladesh Institute of Nuclear Agriculture (BINA). Well-soaked seeds of two blackgram varieties were sown at 10 days interval in each pot on August 26, September 6, September 16 and September 26, of 1999. Two varieties sown at four times were arranged in a completely randomized design and replicated five times. The pots were arranged in 1 m apart rows with a distance of 50 cm from pot to pot in a row. One week after the emergence, the seedlings were thinned out to keep a healthy seedling per pot. Plants were watered regularly and mulching was done at a regular interval to preserve soil moisture and to facilitate the aeration in the root zone. Adequate protection measures were taken to keep the plants free from weed and insect pests.
Photosynthetic gas exchange characteristics were measured at six growth stages viz. vegetative (25 DAE), flowering (35 DAE), pod filling (45 DAE), early maturity (55 DAE), mid maturity (65 DAE) and late maturity stage (75 DAE) using a portable photosynthesis system (LICOR-6200). Measurement of gas exchange was done following the procedures described by Kubota and Hamid (1992). At each measurement, fully expanded young leaf from top of the canopy was selected. Photosynthesis, stomatal conductance, intercellular CO_2 concentration and respiration were observed at each measurement. Measurements were performed from five individual plants at all growth stages of blackgram. For measurement of respiration, leaf chamber was covered with a thick black cloth in a way that no radiation was entered into the sample leaf. The sample leaf was attached into the leaf chamber of the photosynthetic system and CO_2 evolution rates were recorded for respiration. Leaf chlorophyll was measured by a chlorophyll meter (SPAD-502, Minolta Corp., Ramsey, NJ) during September 6 sowing for observation of chlorophyll degradation of blackgram leaves over times. Data on different parameters were analyzed statistically and means were compared using least significance difference (LSD) test.

Results and Discussion

Photosynthesis: Photosynthetic rates of two blackgram varieties did not vary markedly. However, the rates of blackgram differed widely over the sowing times and growth stages of blackgram. The effect of sowing time on photosynthetic rates of blackgram was profound in all the growth stages (Fig. 1). The highest photosynthetic rate was recorded on August 26 sowing and decreased with the delay in sowing times. The lower photosynthetic rates of late sown blackgram on September 6, September 16 and September 26 may be due to lower stomatal conductance derived from higher vapor pressure deficit (Nishimura *et al.*, 2000; Hirai *et al.*, 2000) and lower air temperature during the growth periods (Hamid *et al.*, 1991; Bell *et al.*, 1994). Relative humidity and temperature regimes of different sowing environments during the study periods revealed the same phenomenon (data not shown). Regardless the sowing date, both the varieties showed the highest photosynthetic rate at flowering stage and then a gradual decrease with the increase in plant age. Srinivason *et al.* (1985) also found similar trend in photosynthetic rates of mungbean genotypes. Mitra and Ghildiyal (1988) showed

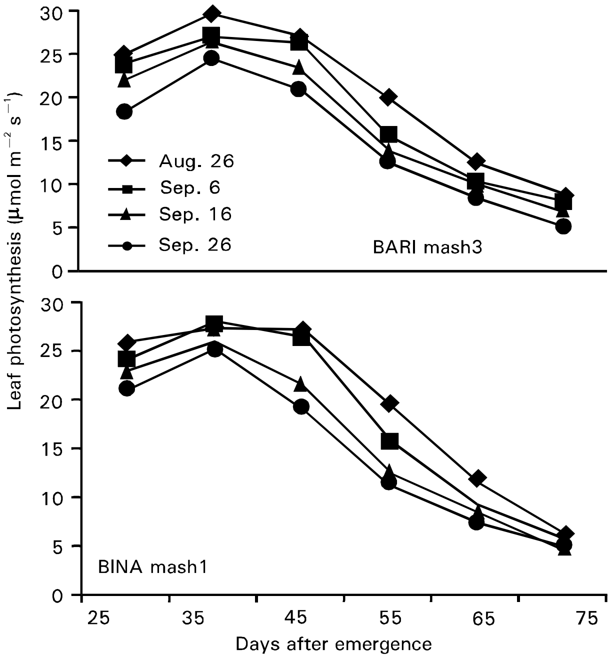

Fig. 1: Sowing time effects on mesophyll conductance of two blackgram varieties at different growth stages.

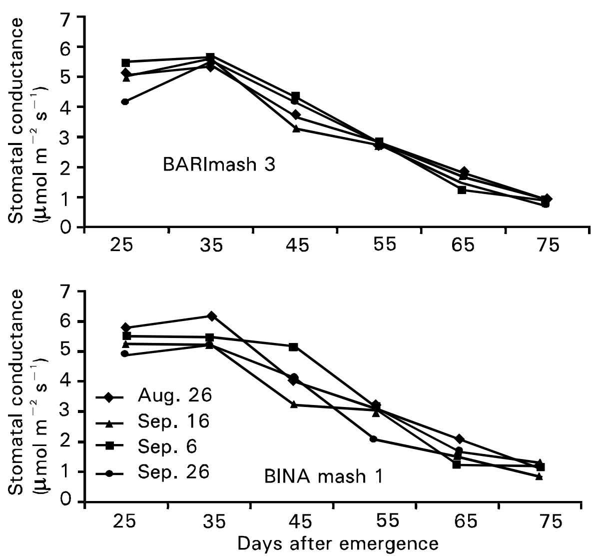

Fig. 2: Stomatal conductance of two blackgram varieties as affected by sowing times over growth periods.

that leaf photosynthetic rate in mungbean is low at the beginning, which increased progressively reaching peak at the flowering stage and then started to decline. The highest photosynthetic rate of blackgram was observed at flowering stage may be explained by higher chlorophyll content of leaves. Fig. 5A indicates the positive correlation (r = 0.86) between chlorophyll content and leaf photosynthesis of blackgram. Ma *et al.* (1995) also reported a positive correlation (r = 0.75) between leaf photosynthesis and chlorophyll (SPAD-502 meter reading) in soybean.

Stomatal conductance: Stomatal conductance resembled the photosynthetic rates over the sowing times and growth periods of blackgram (Fig. 2). There was a positive correlation (r = 0.93)

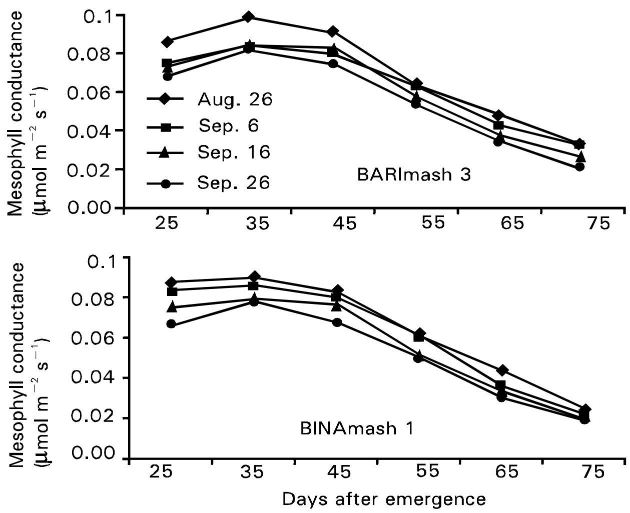

Fig. 3: Sowing time effects on mesophyll conductance of two blackgram varieties at different growth stages.

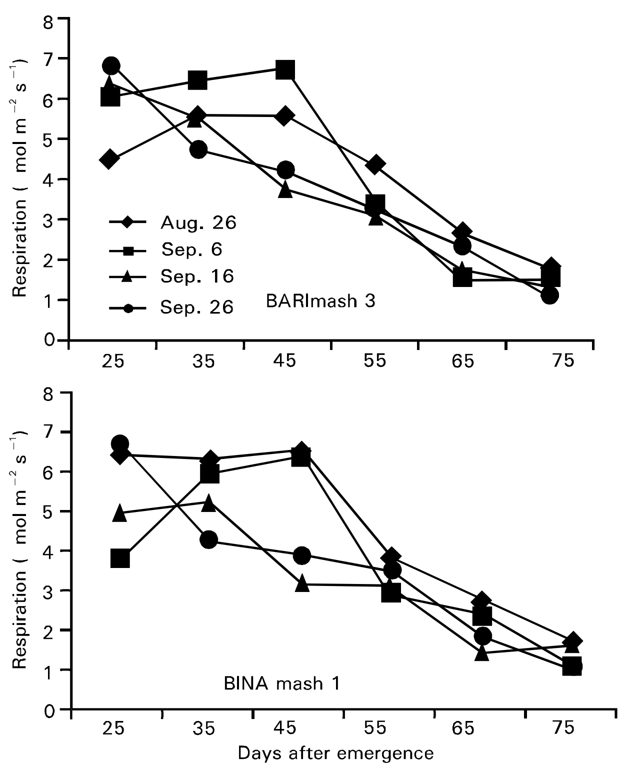

Fig. 4: Sowing time effects on dark respiration of two blackgram varieties at different growth periods.

between stomatal conductance and leaf photosynthesis of blackgram (Fig. 5B). Regardless the variety and sowing time, higher stomatal conductance was observed at flowering stage and then it started to decline sharply at other growth stages which continued till maturity. The decrease in stomatal conductance in the later part of growth periods is due to loss of integrity of chloroplast with the increase in plant age (Thornton and Wample, 1980). BINAmash 1 and BARImash 3 showed similar stomatal conductance in all the growth periods. At flowering stage, the

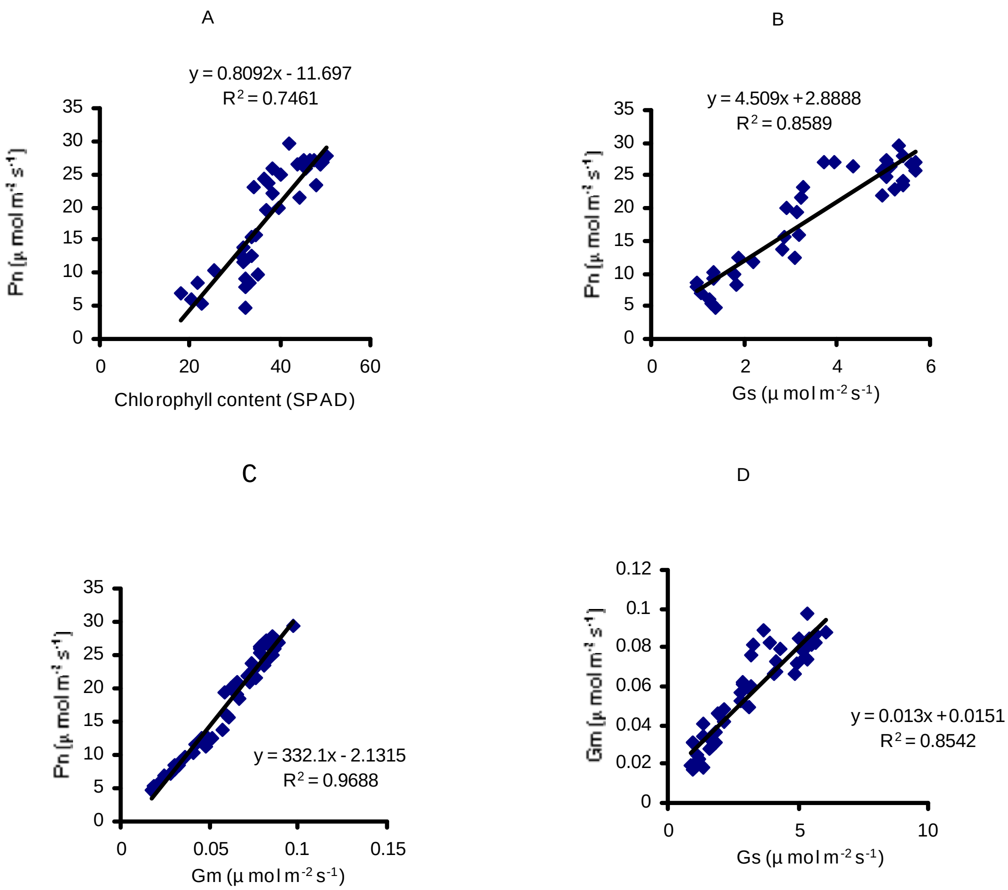

Fig. 5: Functional relationship between (A) leaf chlorophyll content and photosynthesis, (B) stomatal conductance and photosynthesis, ©mesophyll conductance and photosynthesis and (D) Stomatal conductance and mesophyll conductance of blackgram.

highest stomatal conductance (5.668 μ mol m^{-2} s^{-1}) was recorded from BARImash 3 sown on September 6 and 6.096 μ mol m^{-2} s^{-1} from BINAmash 1 sown on same time. However, a great deal of fluctuation in stomatal conductance was observed in BINAmash 1 over the sowing times and growth stages.

Intercellular CO_2 concentration: There is no varietal difference in intercellular CO_2 concentration in blackgram leaves and it fluctuated from 238 to 336 ppm over the growth periods (Table 1). Sowing times showed significant effect on intercellular CO_2 concentration in all the growth periods except at vegetative, pod filling and maturity stages of blackgram. During flowering, the lowest intercellular CO_2 concentration (280 ppm) was observed in September 6 sowing which was similar to August 26 sowing. The highest intercellular CO_2 concentration (305 ppm) at flowering stage was observed in September 26 sowing of blackgram. Among the growth stages, the highest intercellular CO_2 concentration was observed at pod filling stage in all sowing times of blackgram. Higher intercellular CO_2 concentration might have inhibited the photosynthesis of blackgram leaves at the later phase of growth (Hassan, 1993).

Mesophyll conductance: Mesophyll conductance of blackgram did not vary due to variety but sowing time had significant effect on mesophyll conductance over the growth stages (Fig. 3). A strong positive correlation (r = 0.98) was found between mesophyll conductance and leaf photosynthesis (Fig. 5C). The highest mesophyll conductance was found at August 26 sowing and gradually decreased with delay in sowing time. The delay in sowing showed lower mesophyll conductance. It might be due to gradual decrease in atmospheric relative humidity which caused lower stomatal conductance. Fig. 5D indicates a positive correlation (r = 0.92) between stomatal conductance and mesophyll conductance. Similar result was also reported by Islam (1992) in mungbean. Irrespective of variety and sowing time, the highest mesophyll conductance was found at flowering stage and then decreased with increase in plant age.

Table 1: Effect of sowing dates on intercellular CO_2 concentration of blackgram during summer season of 1999.

Sowing dates	Growth periods (Days after emergence)					
	25	35	45	55	65	75
August 26	300	281	303	327	275	268
September 06	318	280	328	260	261	268
September 16	305	293	334	245	270	267
September 26	302	305	336	238	257	267
LSD (0.05)	NS	14.99	NS	20.39	11.95	NS
CV (%)	7.53	5.68	7.99	8.37	4.93	3.62

Respiration: Respiration rates of blackgram did not vary widely due to its varietal difference. But there was great variation in respiration over sowing times and growth stages of blackgram (Fig. 4). Respiration rates of blackgram were higher at early part and decreased gradually in the later part of growth. Respiration rate of BARImash 3 sown on August 26 was 4.501 μ mol m^{-2} s^{-1} at vegetative stage which increased a little at flowering stage and then decreased sharply over time. Similar trend of respiration was also observed in case of other times of sowing with some fluctuation rates. BINAmash 1 showed the highest respiration rates for September 26 sowing at flowering stage and decreased afterwards. Hassan (1993) however, observed higher respiration rates at pod filling stage of blackgram. Higher respiration rates at early part of growth of blackgram may be attributed to use of some energy for synthesis of new materials for development of structural organs of blackgram. In the later part of growth, only the maintenance respiration may accomplish with the decrease in respiration rate of blackgram.

Blackgram is tropical crop and grows well under a bit higher temperature. Gas exchange characteristics of early sown blackgram operated better under higher temperature and higher atmospheric relative humidity than that of delayed sown, under lower temperature and lower atmospheric relative humidity conditions. Gas exchange characteristics of blackgram was also the highest during flowering stage. Therefore sowing time of blackgram should be adjusted in such a way that it prevails higher temperature during its growing periods especially at the flowering stage.

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