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RELATIONSHIPS OF PHOTOSYNTHETIC RELATED PARAMETERS AND YIELD OF SUMMER MUNGBEAN VARIETIES/MUTANTS

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ABSTRACT

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A pot experiment was conducted to evaluate 20 summer mungbean genotypes (5 varieties and 15 mutants). Higher photosynthetic rate (P_N) at grain growth stage was observed in most of the high yielding genotypes. However, yield of 20 mungbean genotypes were not correlated with P_N. Yield was positively correlated with leaf area (0.560*) and total dry matter (TDM) plant^{-1} (0.869**). Positive relationship between P_N and leaf conductance (Gl) (0.452*), Gl and transpiration rate (Tr) (0.916**), leaf area and TDM (0.474*), CO_2_S (sample chamber CO_2) and vapor pressure deficit (VpdL) (0.622**) and negative relationship between Gl and water use efficiency (WUE) (-0.648**), Tr and WUE (-0.754**), Ci/Ca (intercellular CO_2/ambient CO_2) and CO_2_S (-0.484*), Ci/Ca and VpdL (-0.458*), P_N and CO_2_S (-0.605**) were observed. Higher P_N and higher WUE in high yielding mutants, MBM-18 and MBM-292 showed the superiority among the mutants/varieties studied. And also suggests the suitability of these mutants in cultivating under water stress and optimum soil moisture conditions. Higher WUE in the mutants, MBM-21, MBM-249, MBM-302 and N_4I-913 indicates suitability of these mutants for only water stress condition. Higher P_N, higher transpiration rate and medium WUE in the high yielding varieties, Binamoog-5, Binamoog-6 and Binamoog-7 showed the capability of these genotypes to produce high yield under optimum soil moisture condition.

Key words: *leaf area, leaf conductance, mungbean yield, photosynthesis, total dry matter, transpiration and water use efficiency*

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the most important crops of global economic importance. It is prized among the pulse species for its seeds are high in essential dietary protein, easily digested and low production of flatulence when consumed as food (Lakhanpaul *et al*. 2000). It has raceme type of inflorescence with asynchronous flowering and poding. It has yield potential of around 2000 kg ha^{-1} but productivity is low (864 kg ha^{-1}). There are many reasons for such low yield: the varieties grown are generally low yield potential, susceptible to pests and diseases, 70-90% of mungbean flowers doing not develop into mature pods, less responsive to high inputs and limiting sources (Kuo *et al.* 1978). The number of fruits with developing seeds increases after fruit setting stage and reaches to maximum seed growth stage but during this period the plant is still growing vegetative. Therefore, developing reproductive sinks are competing for assimilates with vegetative sinks. Number of fruits and seeds is related with photosynthetic rate that determines through leaf area and dry matter production. Per cent solar radiation interception and rate of dry matter production increased with leaf area development (Hamid *et al.* 1990). In order to improve the production potential, selection of genotypes based on their leaf photosynthetic rates has been practiced in peas (Mahon *et al*. 1981). Mungbean yield is predetermined by the potential of a given variety and the environment. When physiological basis of yield and yield-forming components are understood, it is possible to improve yields of a mungbean crop. Bangladesh Institute of Nuclear Agriculture (BINA) has developed several summer mungbean varieties and promising mutants using nuclear techniques. Bangladesh Agriculture Research Institute (BARI) also developed several varieties. These mungbean mutants/varieties are needed to be assessed for their suitability with respect to photosynthetic and yield related parameters.

MATERIAL AND METHODS

A pot experiment was conducted to evaluate summer mungbean genotypes during March to May 2009 at BINA, Mymensingh, Bangladesh. Five summer mungbean varieties *viz*. BARImung-5, Binamoog-2, Binamoog-5, Binamoog-6, Binamoog-7 and fifteen mutants *viz*. MBM-18, MBM-21, MBM-249, MBM-302, E_4I-915, N_4J-210, N_4J-207, N_2M-402, E_1J-608, E_5M-511, N_5I-913, MBM-347, MBM-292, MBM-7, N_5J-521 were used in this study. Each pot contained 8 Kg of soils (Silty loam, organic matter 1.05%, total N 0.07%, available P 14.3 ppm, exchangeable K 0.25 meq. per 100g soil, available S 13.2 and soil pH 6.67). The experiment was laid out in a Randomized Complete Block design with three replications. Recommended doses of fertilizers were applied and other cultural practices were followed as and when necessary. Leaf area was measured by leaf area meter (Li-3000A, *LI-COR Inc.,* Lincoln, NE, USA). Photosynthetic and microclimatic parameters were recorded using *Portable Photosynthesis System LI-6400XT, LI-COR Inc.,* Lincoln, NE, USA. Statistical analysis was done as per design used with the help of MSTAT computer packages. Duncan’s Multiple Range Test (DMRT) compared the means at 5% level of significance.

RESULTS

Results revealed that the genotype N_4I-913 had the highest photosynthetic rate and E_4I-915, E_4M-511 and MBM-347 had the lowest (Table 1). Maximum conductance and transpiration rate were observed in N_2M-402. BARImung-5 produced the highest leaf area which was identical to those of Binamoog-5, Binamoog-6, Binamoog-7, MBM-18, N_4J-210 and E_4M-511. The mutant E_1J-608 produced the highest TDM which was statistically similar to those of MBM-18, MBM-249, E_4I-915 and E_1J-608. Binamoog-7 showed the highest seed yield which was identical to those of Binamoog-5, Binamoog-6, MBM-18, N_4J-210, N_4J-207, E_1J-608 and MBM-292. High P_N at grain development stage was observed in most of the high yielding genotypes. However, yield of 20 mungbean genotypes were not correlated with P_N. Yield was positively correlated with leaf area (0.560*) and TDM plant^{-1} (0.869**) (Table 2). Mean values 39.42 (Tleaf^{o}C), 71.27 (RH_S%**)**, 1215 (PARi**)** 333 (CO_2_S**)**, 0.688 (Ci/Ca) and 1.33 (VpdL) were observed. Positive relationship between P_N and Gl (0.452*), Gl and Tr (0.916**), leaf area and TDM (0.474*), CO_2_S and VpdL (0.622**) and negative relationship between Gl and WUE (-0.648**), Tr and WUE (-0.754**), Ci/Ca and CO_2_S (-0.484*), Ci/Ca and VpdL (-0.458*), P_N and CO_2_S (-0.605**) were observed.

DISCUSSION

Three high yielding varieties (Binamoog-5, Binamoog-6 and Binamoog-7) and five mutants (MBM-18, N_4J-210, N_4J-207, E_1J-608 and MBM-292) showed higher photosynthetic rate and higher yield. However, relationship between photosynthetic rates and yields of 20 genotypes were not significant. It is generally considered that, for high yielding, high photosynthetic potentials are necessary. However, photosynthetic rates are not always correlated with economic yield of the crop (Curtis *et al*. 1969) and Rhodes (1972). This inconsistent behavior may be because of changes in the relationship between the two factors (photosynthesis and yield) with growth stages or because of high susceptibility of the photosynthetic process to change the environmental factors over a short period (Islam *et al.* 1994). Different genotypic response is also to be considered. Photosynthesis has generally considered being the primary factor affecting the dry matter production in crop plants. The dry matter production and its subsequent conversion into economic yield are the result of a complex physiological process within plants. In mungbean, seed yield has been reported to be significantly related to the leaf photosynthetic rates of the crop at early pod development stage, whereas, there was no significant relationship between the two parameters at vegetative stage (Srinivasan *et al*. 1985). In present study, seed yield was correlated with leaf area and total dry matter plant^{-1}. Although photosynthetic rates are generally expressed as CO_2 uptake per unit leaf area per unit time, but sometimes the total leaf area of a plant is called the photosynthetic potential of the plant. The selection of new cultivars for higher productivity needs ideotypes of appropriate leaves with ontogeny of photosynthetic apparatus (Ticha 1985). Positive relationship between P_N and Gl (0.452*), Gl and Tr (0.916**), leaf area and TDM (0.474*), CO_2_S and VpdL (0.622**) and negative relationship between Gl and WUE (-0.648**), Tr and WUE (-0.754**), Ci/Ca and CO_2_S (-0.484*), Ci/Ca and VpdL (-0.458*), P_N and CO_2_S (-0.605**) suggest that there is ample scope of yield improvement in mungbean by manipulated its related factors. In mungbean, conductance bears significant importance in the photosynthetic process. Higher P_N and higher WUE in high yielding mutants, MBM-18 and MBM-292 showed their superiority both for optimum and water stress. Higher WUE in the mutants, MBM-21, MBM-249, MBM-302 and N_4I-913 indicates suitability of these mutants for water stress. Higher P_N, higher transpiration rate and medium WUE in the high yielding varieties, Binamoog-5, Binamoog-6 and Binamoog-7 showed the capability of these genotypes to produce high yield under optimum soil moisture condition. These results suggest help in selecting mungbean varieties for their cultivation in rainfed residual soil moisture, generally prevails for mungbean cultivation in the South East Asia.

Table 1. Photosynthesis, conductance, transpiration, leaf area, WUE of summer mungbean genotypes at grain growth stage and TDM and yield at maturity

Genotypes	P_N	Gl	Tr	Leaf area /plant (cm^2)	TDM /plant (g)	Yield $plant^{-1}$ (g)	WUE
MBM-18	27.3 abc	0.412 def	4.27 e	1913 ab	39.5 a	12.6 abc	6.50 ab
MBM-21	25.6 abc	0.443 c-f	4.60 de	1297 e	32.5 cd	10.0 gh	5.59 a-d
MBM-249	26.3 abc	0.319 ef	4.60 de	1396 e	37.7 ab	11.1 d-g	5.97 abc
MBM-302	28.9 ab	0.315 ef	4.47 de	1713 cd	36.8 b	11.5 b-f	6.74 a
E_4I-915	19.8 d	0.285 f	4.67 cde	1686 cd	39.4 a	10.9 e-h	4.44 a-d
N_4J-210	28.8 ab	0.750 ab	7.74 a	1938 ab	30.8 de	11.9 a-e	3.74 cd
N_4J-207	26.8 abc	0.589 a-e	6.65 a-e	1624 d	33.6 c	12.4 a-d	4.18 bcd
N_2M-402	28.7 ab	0.841 a	8.50 a	1383 e	23.2 h	7.3 j	3.38 cd
BARI mung-5	28.9 ab	0.465 b-f	7.13 a-d	1775 a	32.7 cd	11.0 d-g	4.08 bcd
E_1J-608	27.0 abc	0.648 a-d	7.46 ab	1762 bcd	39.6 a	13.1 a	3.66 cd
E_4M-511	20.0 d	0.513 b-f	6.25 a-e	1818 abc	30.8 d	10.4 fgh	3.27 d
N_4I-913	29.4 a	0.598 a-e	6.69 a-e	1347 e	25.7 gh	9.6 hi	4.68 a-d
Binamoog-2	24.7 c	0.497 b-f	5.98 a-e	1594 d	28.4 ef	11.1 d-g	5.94 abc
Binamoog-5	27.2 abc	0.718 abc	7.32 abc	1834 abc	33.7 c	12.4 a-d	4.11 bcd
Binamoog-6	28.8 ab	0.720 abc	7.60 ab	1938 ab	34.0 c	12.9 ab	3.84 cd
Binamoog-7	25.6 abc	0.736 abc	7.37 ab	1914 ab	34.1 c	13.3 a	3.62 cd
MBM-347	18.9 d	0.392 def	4.95 b-e	1724 cd	26.4 fg	8.5 ij	3.89 cd
MBM-292	26.3 abc	0.574 b-f	6.74 a-e	1726 cd	33.8 c	12.9 a	4.51 a-d
MBM-7	25.3 bc	0.536 b-f	6.35 a-e	1706 cd	24.6 gh	8.3 ij	4.31 a-d
N_4J-521	24.3 c	0.4090 b-f	6.09 a-e	1688 cd	36.6 b	11.2 c-g	4.47 a-d

Values having common letter(s) in a column do not differ significantly at 5% level by DMRT

Where,
P_N = Photosynthetic rate (µmol$CO_2$$m^{-2}s^{-1}$)
Gl = Leaf conductance (mmol$H_2O$$m^{-2}s^{-1}$)
Tr = Transpiration rate (mmol$H_2O$$m^{-2}s^{-1}$)
TDM = Total dry matter
WUE = Water use efficiency (µmolCO_2 fixed /mmolH_2O)

Table 2. Correlation coefficients between physiological parameters and seed yield of mungbean genotypes

	P_N	Gl	Tr	Leaf area	TDM	WUE
Gl	0.452 *					
Tr	0.430	0.916 **				
Leaf area	-0.164	0.060	-0.071			
TDM	0.344	0.183	0.222	0.474 *		
WUE	0.172	-0.648 **	-0.754 **	-0.046	0.068	
Yield	0.187	0.150	0.073	0.560 *	0.869 **	0.168

* = Significant at 5% level, ** = Significant at 1% level

Where,
P_N = Photosynthetic rate (µmol$CO_2$$m^{-2}s^{-1}$)
Gl = Leaf conductance (mmol$H_2O$$m^{-2}s^{-1}$)
Tr = Transpiration rate (mmol$H_2O$$m^{-2}s^{-1}$)
TDM = Total dry matter
WUE = Water use efficiency (µmolCO_2 fixed /mmolH_2O)

Table 3. Microclimatic parameters of mungbean genotypes at grain growth stage

Genotypes	Tleaf°C	RH_S%	PARi	CO_2_S	Ci/Ca	VpdL
MBM-18	39	76	1197	330	0.73	1.01
MBM-21	34	76	1198	336	0.66	1.16
MBM-249	40	74	1195	336	0.56	1.44
MBM-302	39	73	1246	338	0.60	1.30
E_4I-915	38	69	1212	342	0.47	1.62
N_4J-210	38	71	1207	342	0.57	1.89
N_4J-207	38	70	1144	331	0.68	1.19
N_2M-402	41	70	1243	331	0.78	1.32
BARI mung-5	41	69	1248	325	0.80	1.21
E_1J-608	44	73	1245	327	0.59	1.49
E_4M-511	40	73	1243	338	0.79	1.83
N_4I-913	39	74	1251	331	0.73	1.11
Binamoog-2	37	69	1040	333	0.77	1.16
Binamoog-5	35	71	1232	329	0.76	1.08
Binamoog-6	39	59	1309	329	0.74	1.10
Binamoog-7	38	70	1095	336	0.70	1.30
MBM-347	38	68	1255	342	0.74	1.37
MBM-292	41	72	1249	333	0.66	1.43
MBM-7	40	70	1250	333	0.73	1.20
N_4J-521	39	68	1246	336	0.70	1.44
Mean	39.42	71.27	1215	333	0.688	1.33
Std	4.22	6.11	60.25	13.47	0.114	0.30

Where,
Tleaf°C = Temperature of leaf thermocouple (C)
RH_S% = Relative humidity in the sample cell (%)
PARi = Photosynthetically active radiation in-chamber quantum sensor ($\mu molm^{-2}s^{-1}$)
CO_2_S = CO_2 concentration in sample chamber ($\mu molCO_2mol^{-1}$)
Ci/Ca = Intercellular CO_2/Ambient CO_2
VpdL = Vapor pressure deficit based on Leaf temp (KPa)

Table 4. Correlation coefficients between microclimatic parameters and photosynthetic rate of mungbean genotypes at grain growth stage

	Tleaf°C	RH_S%	PARi	CO_2_S	Ci/Ca	VpdL
RH_S	-0.030					
PARi	0.361	-0.196				
CO_2S	-0.329	0.076	-0.112			
Ci/Ca	-0.042	-0.207	0.026	-0.484*		
VpdL	0.273	0.072	0.101	0.622**	-0.458 *	
P_N	0.159	0.050	0.102	-0.605 **	0.092	-0.404

* = Significant at 5% level, ** = Significant at 1% level

Where,
Tleaf°C = Temperature of leaf thermocouple (C)
RH_S% = Relative humidity in the sample cell (%)
PARi = Photosynthetically active radiation in-chamber quantum sensor ($\mu molm^{-2}s^{-1}$)
CO_2_S = CO_2 concentration in sample chamber ($\mu molCO_2mol^{-1}$)
Ci/Ca = Intercellular CO_2/Ambient CO_2
VpdL = Vapor pressure deficit based on Leaf temp (KPa)

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