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Evaluation of Mungbean (*Vigna Radiata* (L.) Wilczek) Genotypes on the Basis of Photosynthesis and Dry Matter Accumulation

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ABSTRACT

The study was carried out to evaluate six mungbean genotypes on the basis of photosynthesis and productivity under two levels of nitrogen. GK3 was found to have highest photosynthesis rate as well as the highest productivity among the six genotypes followed by VC6144A, PDM54 and IPSA25 irrespective of N levels.

Key words: Mungbean, genotypes, photosynthesis.

INTRODUCTION

In the recent years mungbean has registered a steady growth in production as well as area under cultivation in Bangladesh. The crop is potentially useful in improving cropping systems, for it can be grown almost throughout the year. Mungbean can also tolerate drought to a great extent (Lawn and Ahn, 1984). In Bangladesh extensive cultivation of mungbean is constrained by strong competition with rice, particularly during wet season. The major reason lies in the fact that yields of mungbean are much lower compared with that of cereals. Although food legumes are important component of the diets in many Asian countries including Bangladesh and India, no important headway has so far been achieved in developing high yielding genotypes of any one of the 18 important legumes (Wallis and Byth 1998). Currently Bangladesh produces pulses that barely meet 30% of the total requirement. To close the protein gap for the burgeoning population it is necessary that production of pulses be increased. Photosynthesis has generally been considered to be 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. Manipulation of photosynthetic potentials has been practiced to increase crop productivity for a long time. In order to improve the production potential, selection of genotypes based on photosynthetic rates has been practiced in peas (Mahon and Hobbs 1987).

Genotypic variability in photosynthetic rate has been identified within several crop species (Babu *et al*. 1985; Mahon 1990; Biswas *et al*. 2001). Photosynthetic ability was evaluated on cultivars of mungbean and a significantly positive relationship was obtained between yield and photosynthetic rate (Srinivasan *et al*. 1985; Islam 1994). However, information available is not

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sufficient in the field of photosynthesis and productivity in mungbean. Therefore the study was carried out to evaluate the mungbean genotypes from the aspects of photosynthesis and productivity.

MATERIALS AND METHODS

The experiment was conducted in the Environmental Stress Research Site, Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University and was laid out in Completely Randomised Design. Six genotypes viz. VC6153B, VC 6144A, GK 3, PDM 54, IPSA25 and VO 1443A-G were the treatment variables for the experiment. The rows were arranged in north-south direction in a polyvinyl shed. The genotypes were raised under two levels of supplied nitrogen (High N - 154mg/l and Low N - 34 mg/l). Hoagland 3 solution: (3.5 mM $Ca(NO_3)_2$, 5 mM KNO_3, 1 mM KH_2PO_4, 0.99 mM $MgSO_4$, 19 M Fe-citrate and microelements made of 0.154mM N (high N level-HN)) *and* Hoagland 1 solution: (0.5 mM $Ca(NO_3)_2$, 5 mM K_2SO_4, 0.5 mM $Ca(H_2PO_4)_2$, 2 mM $CaSO_4$, 0.99 mM $MgSO_4$, 19 µM Fe_2O_3, and micro-nutrient) made of 0.3414 mM N (low N level-LN) were used as source for nitrogen.

The seeds of selected mungbean genotypes were sown on 13 April 2001 in vermiculite filled net bag. The net bag was inserted in the upper portion of 30 cm long perforated polyvinyl chloride (PVC) pipe sections. Three such PVC sections were tied to a triangular shaped bamboo frame so that the PVC sections can suspend in the nutrient solution. The seedlings were transferred in vessels (size- 20 liter) containing nutrient solutions (Hoagland 3 (high N - 154 mg/l) and Hoagland 1 (low N-34 mg/l) at 14 days after emergence (DAE) on 30 April 2001. Plants were supported in the upper portion by bamboo sticks. Some seedlings were replaced as they failed to survive under changed situation. Each vessel containing three seedlings of the concerned genotype was replicated thrice. One of the three plants from each vessel was harvested at 35 DAE i.e. 3 weeks after transferring in nutrient solution. Another was harvested at 49 DAE i.e. 5 weeks after transferring in nutrient solution. The remaining one was kept in the container up to maturity (c. 63 days). The pH of the solution was maintained at 6.5 by adding required amount of 4N H_2SO_4. The nutrient solution was changed twice in a week and was aerated continuously using air pump to maintain sufficient oxygen for root respiration and to provide solution mixing.

Photosynthesis was measured at vegetative, flowering, pod filling and maturity stage using fully expanded leaf (the third from the top) with a portable Photosynthesis System (Model: LiCOR-6200) assembled with an Infra Red Gas Analyzer (IRGA) and data logger following the procedure described by Kubota and Hamid (1992). The size of clamp-on assimilation chamber of was kept fixed at 6.25 cm^2. A metal halide lamp of 150 W was used to obtain a photosynthetic active radiation (PAR) of 1500 µmol m^{-2} s^{-1} during the measurement. Airflow through the chamber was 400 ml min^{-1}; relative humidity (RH) of air supplied in the chamber was adjusted to 50% and chamber temperature was maintained at $30^oC \pm 1$. Photosynthesis data was recorded from 9:30 to 3:00 pm in a steady-state condition after the leaf was placed in the chamber. Net photosynthesis rate (Pn), leaf conductance (Cs), and other related parameters were available as computer output attached to the system. Leaf area was measured by an automatic leaf area meter (Model AAM 8, Hayashi Denko, Japan).

RESULTS AND DISCUSSION

Dry matter accumulation

Appreciable inter and intra-genotypic variations in dry matter accumulation were observed among mungbean genotypes throughout the growth phases under both high and low nitrogen level. Total dry matter (TDM) and plant organs DM at harvest varied significantly among genotypes (Figure 1& 2).

All the treatments gave a mean value of plant dry mass of 38510 mg and 45530 mg under low N and high N level, respectively. Hence an increased nitrogen supply induced an increase in dry matter production by some 18 per cent that corresponds to the generally positive effects of this nutrient.

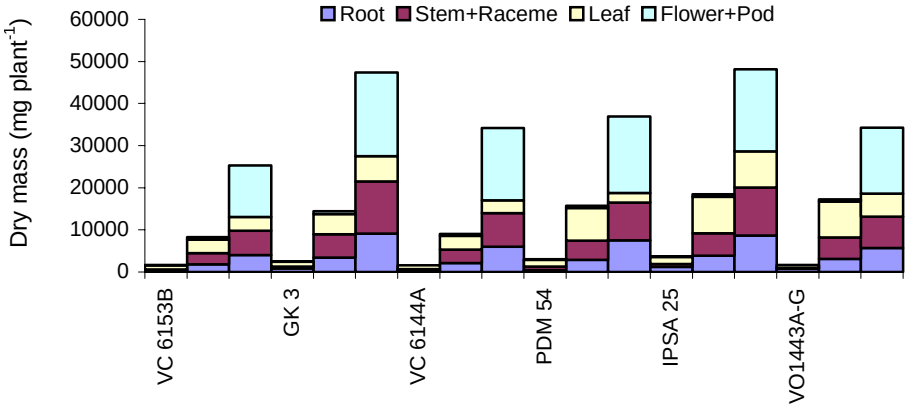

Figure 1. Variation in dry mass accumulation in plant parts among mungbean genotypes over time grown in solution under low nitrogen level

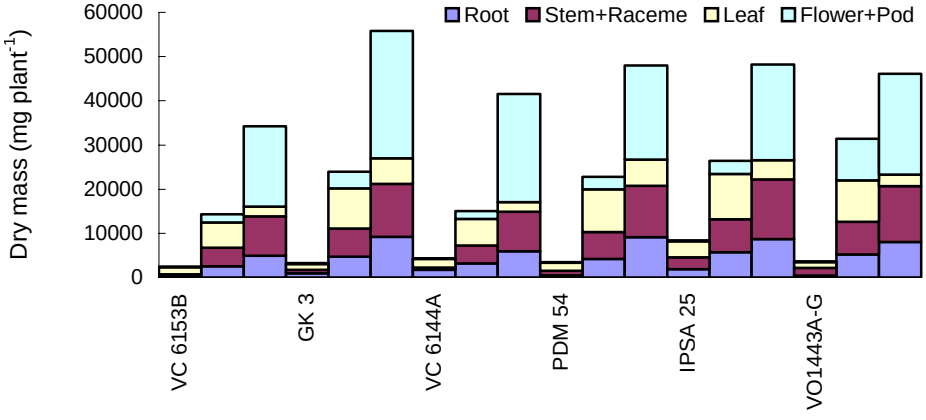

Figure 2. Variation in dry mass accumulation in plant parts among mungbean genotypes over time grown in solution under high nitrogen level

Under high N level high vigor genotypes attained higher growth rate and accumulated more dry matter than low vigor ones (except VC6153 and VC6144A). PDM 54 had more dry mass accumulation at the earlier phases till flowering (35 DAE) followed by VO 1443A-G and thereafter GK 3 took the lead and sustained till maturity. VC 6153B had consistently lower dry mass yield throughout the growth phases as its leaf senescence started earlier. But GK3 had consistently higher dry mass yield throughout the growth phases. Kuo *et al*. (1978) hypothesized that the genotypes having lower dry mass accumulation in the vegetative stage are lower yielder.

At low nitrogen supply, the maximum biomass of the low productive and high productive species differ significantly (Table 1). This is in agreement with data from the short-term experiments which show that species with an inherently high potential productivity have also in low-nutrient environments an equal or even a higher biomass production than species with inherently low-potential productivity (Clark 1983; Bushby and Lawn 1992; Berendse 1994). Among the high growth genotypes, in GK3 higher percentage of dry mass was accumulated in seed at high N level comparative to that in low N level but it was higher than other genotypes in low N level. Among the low growth ones, in IPSA25 higher percentage of dry mass was accumulated in seed under high N level comparative to that in low N level. Relatively higher percentage of dry mass in IPSA25 was shifted to roots under low N level (Table 1). Moreover, GK3 out yielded all the genotypes in TDM, seed yield and total N uptake irrespective of N-level.

Table 1. Growth and yield attributes of mungbean genotypes at maturity as influenced by N levels grown in solution

Genotypes	N-level	Root wt. (g)	Shoot wt. (g)	LA (cm)	TDM (g)	Seed pod^{-1}	Seed plant^{-1}	100 seed wt. (g)	Seed yield (g plant^{-1})	Total N (%)	Total N uptake (g plant^{-1})
VC6153B	N1*	4.01	21.29	410.91	25.30	7.8	250	5.14	5.54	2.31	0.58
	N2	4.91	29.32	355.48	34.24	8.3	400	5.70	12.74	2.64	0.90
GK3	N1	7.55	41.00	532.40	48.55	7.7	454	4.53	15.89	2.30	1.12
	N2	9.20	46.58	780.80	55.78	7.9	488	4.94	21.43	2.87	1.60
VC6144A	N1	5.97	28.21	502.98	34.18	7.3	199	6.93	12.23	2.13	0.73
	N2	5.15	35.56	272.10	40.71	7.7	277	7.42	18.12	2.56	1.04
PDM54	N1	9.15	33.97	766.78	43.12	8.7	388	3.83	13.26	1.96	0.84
	N2	7.27	38.38	643.43	45.61	8.8	463	3.87	16.16	2.23	1.02
IPSA25	N1	8.65	37.80	1236.43	46.45	8.2	467	3.42	14.33	2.09	0.97
	N2	7.78	39.18	500.05	49.96	8.8	503	3.70	16.33	2.17	1.02
VO1443A-G	N1	5.71	28.56	519.79	34.27	6.9	321	3.62	9.81	2.00	0.68
	N2	8.01	36.73	255.38	44.74	8.7	478	3.87	18.12	2.03	0.91
LSD $_{0.01}$		0.422	1.897	47.90	7.7	NS	150	0.232	1.863	0.17	0.093
CV (%)		6.53	5.80	9.10	18.02	15.86	41.18	5.23	12.58	5.78	7.13

**Nitrogen level: N1 = 34ppm/l, N2 = 154ppm/l*

Variation in nitrogen content in different plant parts

Nitrogen content differed among the plant parts and it fluctuates with the growth of the plant (Table 1). Nitrogen uptake was highest in GK3 irrespective of growth stages and N level. This indicates higher plasticity of the genotype to meet their nutrient demand under changed situation. Since the total amount of nitrogen of plant at harvesting was larger than that of pod filling stage, it is assumed that the major parts of nitrogen absorbed during the period of reproductive growth were highly translocated from leaf into grain.

In our present study it was observed that nitrogen content of the plant reduced with the aging of the plant. The percentage of nitrogen in different genotypes reduced in the order of 49 DAE<63 DAE<35 DAE. With the increase in dry matter the N content of the plant significantly reduced in different genotypes up to pod filling stage, irrespective of N levels. But at harvest the N content of the plant increased due to higher concentration of N in seeds. Similar observation was made by Trung and Yoshida (1982) in mungbean grown in solution culture.

Leaf photosynthesis

The production of biomass and grain yield of pulse crops can largely be accounted for by photosynthesis during growth and maturation. It is generally considered that for high yield, high photosynthetic potentials are necessary. 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 the present study great differences in photosynthetic rates and its related parameters among the six genotypes were observed. Among all the parameters mesophyll conductance had the highest correlation with photosynthesis (Table 2). Leaf photosynthesis (Pn) of six mungbean genotypes at different growth stages under two N levels are shown in Figures 3 & 4. It was observed that Pn was highest at flowering stage and then gradually decreased over time irrespective of genotypic difference and nitrogen level (Figure 3 & 4). Under optimal N level Pn rates ranged from 12.92 µmol m^{-2} s^{-1} (VO1443A-G) to 22.63 µmol m^{-2} s^{-1} (GK3), 15.26 µmol m^{-2} s^{-1} (VO1443A-G) to 41.42 µmol m^{-2} s^{-1} and 7.16 µmol m^{-2} s^{-1} (IPSA25) to18.60 µmol m^{-2} s^{-1} (GK3) at vegetative, flowering and pod filling stage, respectively (Table 3). Under sub-optimal N level photosynthetic rate was lower than the optimal N level irrespective of genotype. Mesophyll conductance had the highest variability among the genotypes in different growth stages (Table 3).

Table 2. R^2 value of functional relationship between photosynthesis (Pn) and mesophyll conductance (Cm) among six mungbean genotypes

Genotype	N-level	Regression equation	R^2-value
VC6153B	N1*	y = 3.5952x + 3.383	0.7260
	N2	y = 8.7974x + 3.6195	0.3201
GK3	N1	y = 8.6033x + 11.262	0.9788
	N2	y = 14.892x – 8.5062	0.5202
VC6144A	N1	y = 4.0366x + 12.694	0.8206
	N2	y = 7.1487x + 4.6487	0.3256
PDM54	N1	y = 8.4232x + 1.7347	0.9399
	N2	y = 4.052x + 4.6834	0.5768
IPSA25	N1	y= 10.294x + 0.9599	0.9828
	N2	y = 18.385x – 7.633	0.7220
VO1443A-G	N1	y = 4.726x + 5.7007	0.6319
	N2	y = 2.1777x + 6.1767	0.5195

**Nitrogen level: N1-34ppm/l, N2-154ppm/l*

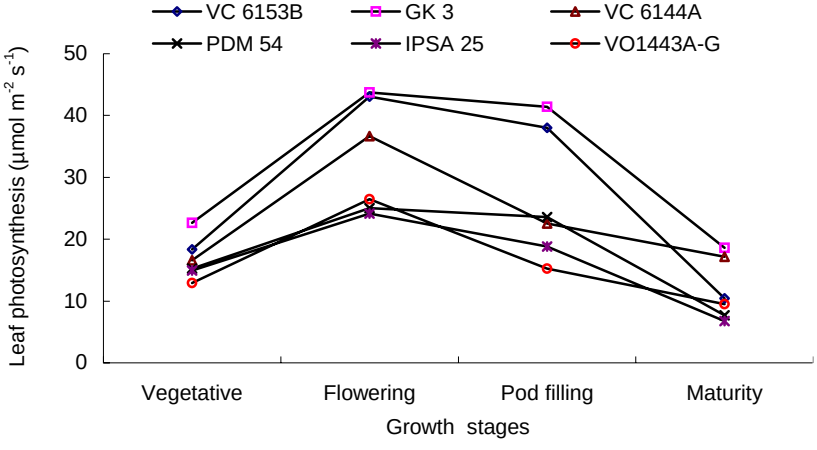

Figure 3. Influence of high N on leaf photosynthesis over time in mungbean genotypes grown in solution

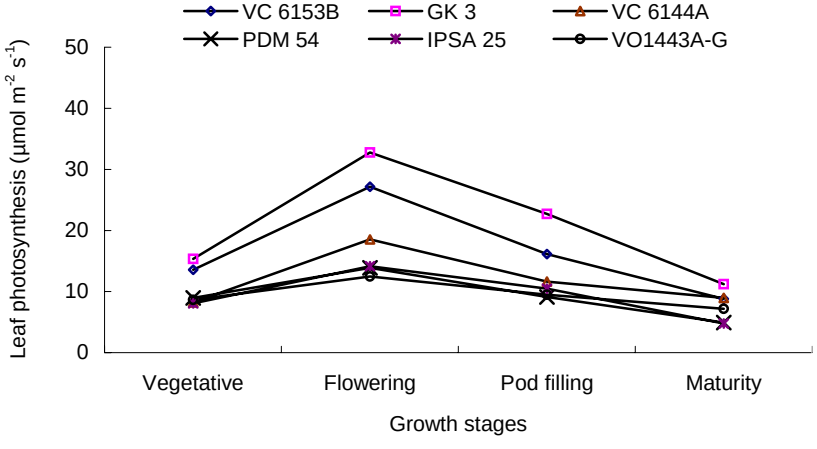

Figure 4. Influence of low N on leaf photosynthesis over time in mungbean genotypes grown in solution

Table 3. Effect of N levels on leaf photosynthesis and its related parameters in mungbean genotypes

Genotype	Pn (μ mol $m^{-2}s^{-1}$)		Cm (mol $m^{-2}s^{-1}$)		Ci (ppm)		Cs (mol $m^{-2}s^{-1}$)	
	High N	Low N	High N	Low N	High N	Low N	High N	Low N
Vegetative stage								
VC6153B	18.34	13.57	0.450	0.450	281.9	288.6	1.141	1.141
GK 3	22.63	15.34	0.528	0.611	297.7	286.6	1.326	1.553
VC6144A	16.59	8.22	0.524	0.343	260.9	311.2	1.309	0.878
PDM 54	15.26	8.93	0.631	0.427	324.8	323.6	1.595	1.094
IPSA 25	14.93	8.04	0.516	0.331	304.8	330.6	1.310	0.838
VO1443A-G	12.92	8.65	0.331	0.289	330.6	310.3	0.838	0.740
$LSD_{(0.05)}$	1.45	1.36	0.04	0.05	11.23	7.67	0.11	0.13
CV %	18.41	27.63	18.31	25.92	7.97	5.30	18.28	25.84
Flowering stage								
VC6153B	43.09	27.19	2.068	0.629	295.4	271.5	5.144	1.607
GK 3	43.75	32.75	2.409	0.877	296.8	271.6	3.996	2.233
VC6144A	36.68	18.34	2.068	0.528	295.4	297.7	5.016	1.326
PDM 54	25.03	13.90	1.202	0.744	343.9	361.5	2.985	1.827
IPSA 25	24.17	14.12	0.877	0.392	302.6	289.6	2.171	0.970
VO1443A-G	26.45	12.46	1.464	0.868	317.9	365.2	3.667	2.159
$LSD_{(0.05)}$	3.91	3.56	0.25	0.08	8.26	18.40	0.49	0.21
CV %	25.84	38.35	32.12	26.15	5.70	12.67	27.49	26.44
Pod filling stage								
VC6153B	38.02	16.13	3.459	0.734	314.1	317.8	8.601	1.878
GK 3	41.42	22.73	1.289	0.910	274.0	325.0	3.209	2.263
VC6144A	22.53	11.63	1.474	0.357	341.3	329.1	3.663	0.888
PDM 54	23.58	9.12	0.917	0.363	309.7	309.9	2.272	0.901
IPSA 25	18.84	10.45	0.740	0.582	301.3	259.7	1.867	1.447
VO1443A-G	15.26	9.46	0.399	0.410	283.9	300.3	1.016	1.018
$LSD_{(0.05)}$	3.91	3.56	0.25	0.08	8.26	18.40	0.49	0.21
CV %	36.45	36.45	72.03	36.85	7.15	7.55	71.70	37.31
Maturity stage								
VC6153B	10.46	8.78	0.311	0.283	303.3	302.9	0.796	0.727
GK 3	18.61	11.22	0.362	0.497	257.1	295.8	0.926	1.265
VC6144A	17.15	9.50	0.179	0.246	210.4	286.0	0.460	0.630
PDM 54	7.70	7.70	0.320	0.354	311.1	315.0	0.821	0.907
IPSA 25	7.16	6.77	0.220	1.112	299.5	395.7	0.565	2.756
VO1443A-G	9.50	6.07	0.266	0.220	279.9	299.5	0.682	0.565
$LSD_{(0.05)}$	2.10	0.81	0.03	0.15	16.26	17.25	0.07	0.36
CV %	38.10	20.74	22.46	68.36	12.51	11.64	22.32	66.29

Notes: Pn- photosynthesis, Cm- Mesophyll conductance, Ci- Internal CO_2 conc., Cs- Stomatal conductance

Maximum crop growth rate has been reported to be synchronous with the maximum leaf mass after flowering. Canopy development in mungbean was observed to be very slow till flowering stage by Kuo *et al*. 1978. Moreover Hamid *et al*. (1990) observed that at around maturity, the

photosynthetic rate dropped to about 25% of its maximum. Excessive leaf area during later stages of growth was found to be detrimental to yield in mungbean. In the present study IPSA25 produced excessive leaf area but it had lower seed yield in low N level (Table 1). But higher photosynthetic rate does not guarantee higher seed yield (Curtis *et al*. 1969) as differential chlorophyll content makes differences in the photosynthetic rates in leaves, while the length of the growth cycle determines the amount of dry matter production and partitioning in plant parts.

CONCLUSION

In the present study, GK3 was found to have the highest photosynthesis rate as well as the highest productivity among the six genotypes followed by VC6144A, PDM54 and IPSA25 irrespective of N levels. This genotype may be selected as potential mungbean genotype for commercial cultivation both under low and high N environment.

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