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Effect of date of sowing on nodulation, growth, thermal requirement and grain yield of *kharif* mungbean genotypes

GURIQBAL SINGH, H.S. SEKHON, HARI RAM, K.K. GILL* and POONAM SHARMA

*Department of Plant Breeding and Genetics, *Department of Agricultural Meteorology, Punjab Agricultural University, Ludhiana 141 004, Punjab, India; E-mail: singhguriqbal@rediffmail.com*

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ABSTRACT

A field experiment was carried out during *kharif* 2005 and 2006 to study the effect of different dates of sowing on nodulation, growth and yield of four mungbean genotypes 'SML 668', 'ML 818', 'ML 1265' and 'ML 1405'. There was a drastic reduction in yield in case of August 5 sowing in both the years compared to July sowing. Genotype 'ML 1265' produced higher yield than 'SML 668' in both the years. Interaction between dates of sowing and genotypes for grain yield was significant in 2005. Genotype 'ML 1265' produced significantly higher yield than the other genotypes under late sowing of August 5. Early sowing resulted in absorbing sufficient amount of heat units in less time as compared to late sowings which acquired more days to mature during 2006 as compared to 2005 and resulted in accumulation of more growing degree days (GDD) as compared to first season. Among genotypes 'SML 668' followed by 'ML 1265' consumed lesser days to attain 50% flowering and physiological maturity as compared to other genotypes during both the years. On the basis of two-year mean values, days to 50% flowering were 43.0, 42.0, 41.0 and 39.5 and days to maturity were 70.5, 69.0, 65.5 and 63.0 in July 5, 15, 25 and August 5 sowings, respectively. SML 668 was the earliest in maturity (60.5 days) whereas 'ML 818', 'ML 1265' and 'ML 1405' matured in 69.0, 67.5 and 69.6 days, respectively.

Key words: Mungbean, Nodulation, Thermal indices

Mungbean [*Vigna radiata* (L.) Wilczek] is an important pulse crop of *kharif* season in India. The crop is highly sensitive to environment. Therefore, time of sowing shows remarkable influence on the growth and productivity of mungbean in *kharif* due to rainy season (Brar *et al.* 1988). The optimum time of sowing ensures the complete harmony between the vegetative and reproductive phases on one hand, and the climatic rhythm on the other and helps in realizing the potential yield (Singh and Dhingra 1993). Temperature is the prime weather variable which affects plant life. Heat unit concept is the agronomic application of temperature effect on plant, which has been employed to correlate phenological development in crops and to predict maturity dates (Nuttonson 1955, Major *et al.* 1975). Crop phenology is an essential component of the crop-weather models, which can be used to specify the most appropriate rate and time of specific plant growth and development process. The duration of each growth phase determines the accumulation and partitioning of dry matter in different plant organs as well as crop response to environmental factors. The duration of particular stages of growth is directly related to temperature and the duration for particular species could be predicted using the sum of daily air temperature (Wang 1960). The data on the effect of dates of sowing were lacking on the new promising genotypes of mungbean. In addition, there was a dire need to find out genotypes for late sowing according to heat unit requirement. Therefore, an experiment was planned and conducted on different dates of sowing on *kharif* mungbean genotypes, so that these indices can be used as tools for characterizing thermal responses in different cultivars of mungbean.

MATERIALS AND METHODS

The experiment was conducted at the Punjab Agricultural University, Ludhiana (30° 56' N, 75° 52' E, altitude 244 m) in *kharif* 2005 and 2006. The soil of the experimental field was loamy sand, having pH 8.2, organic carbon 0.29%, available phosphorus 14.4 kg/ha and available potassium 318 kg/ha. The experiment was conducted in a split plot design with three replications. The four dates of sowing (July 5, July 15, July 25 and August 5) were kept in the main-plots and four genotypes 'SML 668', 'ML 818', 'ML 1265' and 'ML 1405' were assigned in the sub-plots. The nutrient dose of 12.5 kg/ha N and 40 kg/ha P_2O_5 was applied through urea (46% N) and single superphosphate (16% P_2O_5), respectively at the time of sowing. Sowing was done in rows 30 cm apart. Plant to plant spacing was maintained at about 10 cm by thinning about two weeks after sowing. Weeds were controlled by using pendimethalin @ 0.75 kg/ha as pre-emergence application. All other agronomic practices were adopted according to the package of practices (PAU 2004). The total rainfall of 399.9 mm and 446.1 mm was received during 2005 and 2006, respectively. The data on nodulation, days to 50% flowering, dates to maturity, plant height, branches/plant, pods/plant, seeds/pod, 100-seed weight and grain yield were recorded. The accumulated heat units (GDD) for each day were calculated for different phenological event as per the equation suggested by Nuttonson (1955), using base temperature of 10°C. Heliothermal units (HTU) are the product of growing degree days (GDD) and corresponding actual sunshine hours for that day. Photothermal units (PTU) are the product of growing degree days and corresponding day length hours for that day. GDD, HTU and PTU were accumulated from the date of sowing to each date of observation i.e. 50% flowering and physiological maturity. Heat use efficiency (HUE) for grain yield was computed following the method as described by

Rajput (1980) as below:

HUE= Seed yield/Accumulated heat units

RESULTS AND DISCUSSION

Effect of date of sowing: In both the years, the maximum plant height was recorded in July 5 sowing which was significantly higher than all other sowing dates (Table 1). There was linear decline in plant height with delay in sowing. Branches/plant were not significantly influenced by sowing dates in 2005, however, in 2006, July 5 and July 15 showed significantly higher branches/plant than July 25 and August 5 sowing dates. In 2005, maximum pod/plants were recorded in July 25 sowing which was statistically superior to all other sowing dates. In 2006, significantly higher number of pods/ plant were recorded in July 5 and 15 sowing dates and both were statistically at par. Pod bearing was the least in the case of August 5 sowing date. Differences in seeds/pod due to sowing dates were found to be non-significant in 2005 while in 2006, July 5 and July 15 dates of sowing had significantly higher seeds/pod than July 25 and August 5 sowing dates. The 100-seed weight was found to be non-significant in both the years.

During both the years of the study, nodules and their dry weight were influenced significantly due to dates of sowing (Table 2). In both the years, number of nodules and their dry weight/plant were highest in the case of July 15 while minimum number of nodules and their dry weight were recorded in the case of August 5 sowing. In both the years, date of sowing showed significant effect on the grain yield of mungbean. In 2005, sowing on July 25 gave significantly higher grain yield (1282 kg/ha) than July 5 and August 5 sowings but was statistically at par with July 15 sowing. However, in 2006, significantly higher grain yield (1488 kg/ ha) was recorded in July 15 sowing which was statistically on par with July 5 sowing but significantly superior to July 25 and August 5 sowing dates. There was a drastic reduction in the grain yield in the case of August 5 sowing. Singh *et al.* (2003) revealed that July 12 to 24 was the best sowing time for *kharif* mungbean. In another study, Fraz *et al.* (2006) observed higher grain yield attributes of mungbean in the case of the crop sown in the third week of July than the sowings in third week of June and first week of July. In 2005, due to good rains at vegetative stage the crop attained more plant height, with the result lodging was observed in July 5 and 15 sowings, which caused reduction in grain yield.

With delay in sowing, days to 50% flowering as well as days to maturity were reduced in all the genotypes (Table 3). Two-year mean values of days to 50% flowering were 43.0, 42.0, 41.0 and 39.5 and days to maturity were 70.5, 69.0, 65.5 and 63.0 under July 5, 15, 25 and August 5 sowings, respectively. During 2005, early sown crop availed more growing degree days (GDD), photothermal units (PTU) and heliothermal units (HTU) at physiological maturity and with each delay in sowing GDD, PTU and HTU decreased. Almost similar trend was observed for 50% flowering. However, July 25 sowing had the highest HUE and resulted in highest grain yield. During 2006, the different trend was observed due to occurrence of higher maximum and minimum temperature that probably accelerated the process of development and as a result duration of 50% flowering as well as physiological maturity was shortened by 2-3 days in case of first sowing during 2006 as compared to 2005. So early sowing resulted in absorbing sufficient amount of heat units in short time due to

Table 2. Effect of dates of sowing and genotypes on nodulation and grain yield in *kharif* mungbean

Treatment	Number of nodules/ plant		Dry weight of nodules (mg)/plant		Grain yield (kg/ha)	
	2005	2006	2005	2006	2005	2006
Date of sowing						
July 5	13.7	18.7	36.5	40.7	1111	1372
July 15	22.3	27.7	61.3	56.8	1186	1488
July 25	NR	26.1	NR	54.0	1282	1123
August 5	15.3	17.5	39.8	36.9	983	1063
CD (P=0.05)	2.7	1.1	5.2	3.3	108	119
Genotypes						
SML 668	14.3	20.7	40.8	43.0	1062	1158
ML 818	17.8	22.5	46.4	45.6	1078	1272
ML 1265	19.3	25.1	50.9	53.9	1278	1362
ML 1405	17.3	21.9	49.3	45.8	1145	1255
CD (P=0.05)	1.8	1.6	4.3	2.2	106	63

NR - Not recorded

Table 1. Effect of dates of sowing and genotypes on growth and yield attributing characters of *kharif* mungbean

Treatment	Plant height (cm)			Branches/plant			Pods/plant			Seeds/pod			100- seed weight (g)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Dates of sowing															
July 5	75.5	71.3	73.4	5.38	4.95	5.17	14.7	23.3	19.0	8.78	10.47	9.63	4.08	3.94	4.01
July 15	69.0	60.8	64.9	5.30	5.00	5.15	16.5	24.4	20.5	8.86	10.55	9.71	4.08	3.98	4.03
July 25	60.9	54.6	57.8	5.13	4.63	4.88	18.6	18.6	18.6	8.83	10.12	9.48	4.10	3.52	3.81
August 5	61.1	39.6	50.4	5.10	3.95	4.53	13.6	12.5	13.1	8.86	9.87	9.37	3.99	3.93	3.96
CD (P=0.05)	3.7	3.0	4.9	NS	0.31	0.51	1.1	1.5	1.6	NS	0.30	NS	NS	NS	NS
Genotypes															
SML 668	56.1	43.4	49.8	4.68	4.07	4.38	14.2	14.3	14.3	9.08	9.18	9.13	5.56	5.02	5.29
ML 818	68.2	62.2	65.2	5.43	4.72	5.08	15.7	21.8	18.8	8.86	10.63	9.75	3.58	3.41	3.50
ML 1265	70.0	58.1	64.1	5.36	4.90	5.13	18.3	22.7	20.5	8.83	11.28	10.06	3.75	3.67	3.71
ML 1405	72.3	62.6	67.5	5.43	4.85	5.14	15.2	20.5	17.9	8.86	9.9	9.38	3.36	3.29	3.33
CD (P=0.05)	3.5	2.7	4.2	0.40	0.32	0.23	1.2	1.9	2.1	0.18	0.51	0.43	NS	0.62	0.49

Table 3. Accumulated Growing Degree Days (AGDD), Accumulated Heliothermal Units (AHTU) and Accumulated Photothermal Units (APTU) at 50% flowering and maturity and heat use efficiency at maturity under different dates of sowing and genotypes

Treatment	2005								2006								Heat use efficiency (kg/ha/°C/day)	
	50% Flowering				Maturity				50% Flowering				Maturity					
	Days	AGDD	AHTU	APTU	Days	AGDD	AHTU	APTU	Days	AGDD	AHTU	APTU	Days	AGDD	AHTU	APTU	2005	2006
Dates of sowing																		
July 5	44	880	6240	11870	72	1422	11184	18713	42	837	5244	11468	69	1368	10815	18040	0.79	1.00
July 15	42	858	6647	11406	69	1362	10951	17650	42	851	5961	11317	69	1346	9683	17437	0.87	1.11
July 25	41	825	7081	10795	64	1244	10258	15920	41	798	5502	10453	67	1279	9495	16299	1.04	0.88
August 5	39	759	6871	9738	62	1174	10370	14676	40	776	6050	9946	64	1213	9859	15130	0.84	0.88
Genotypes																		
SML 668	36	718	5708	9514	62	1224	10134	15811	37	791	5116	9842	59	1155	8741	14976	0.88	1.00
ML 818	43	865	7014	11400	68	1330	10849	17159	44	877	6143	11536	72	1380	10591	17660	0.83	0.92
ML 1265	43	863	7002	11367	68	1315	10817	16939	43	829	6004	11360	68	1317	10108	16915	0.97	1.03
ML 1405	44	876	7135	11533	70	1352	11079	17351	40	791	5492	10444	70	1355	10412	17356	0.85	0.92

high temperature but late sowings (July 25 and August 5) acquired more days to mature during 2006 as compared to 2005 and resulted in accumulation of more GDD. During 2006, July 15 sown crop recorded higher grain yield, leading to comparatively better HUE for grain yield as compared to other dates of sowing. This could be due to resource induced competition for attaining physiological maturity in sufficient accumulated heat units.

Performance of genotypes: Among the genotypes 'ML 1405' was the tallest (67.5 cm) whereas 'SML 668' was the shortest (49.8 cm) in height (Table 1). Number of branches/plant and pods/plant were least in 'SML 668'. The highest number of pods/plant was recorded in 'ML 1265' during both the years. 'SML 668' had the highest seed weight (5.29 g/100 seeds) due to its large seed size while in 'ML 1265', 'ML 818' and 'ML 1405' the 100-seed weight was 3.71, 3.50 and 3.33 g, respectively.

Higher numbers of nodules were observed in 'ML 1265' than in 'ML 818', 'ML 1405' and 'SML 668' (Table 2). The dry weight of nodules/plant was also higher in the case of 'ML 1265' than the other genotypes. Genotypes differed significantly in the grain yield during both the years. 'ML 1265' was the highest yielder whereas 'SML 668' was the lowest yielder. Genotype 'ML 1265' gave 20.3% and 17.6% higher grain yield than 'SML 668' in 2005 and 2006, respectively. Genotypes 'ML 1405' and 'ML 818' were on par in yield. Interaction effects regarding dates of sowing and genotypes were significant in 2005. Data showed that 'ML 1265' was superior to other genotypes under late sowing (August 5). Though interaction was non-significant between dates of sowing and genotypes in 2006 yet the trend was almost the same as observed in 2005.

'SML 668' was the earliest in flowering (Table 3). On the basis of two-year mean values, 50% flowering was observed 36.5 days after sowing (DAS) while in 'ML 818', 'ML 1265' and 'ML 1405', 50% flowering occurred 43.5, 43.0 and 42.0 DAS under different dates of sowing. Similarly, two-year mean values of dates to maturity were 60.5, 70.0, 68.0 and 70.0 in 'SML 668', 'ML 818', 'ML 1265' and 'ML 1405', respectively. In different genotypes, high variation in days taken to reach different phenological stages and agroclimatic indices *i.e.* GDD, HTU and PTU was observed during 2005 as well as 2006. 'SML 668' followed by 'ML 1265' consumed lesser days to attain 50% flowering and physiological maturity as compared to other genotypes during both the years. Similarly, 'ML 1265' attained lesser GDD, HTU and PTU units and recorded higher grain yield as compared to other genotypes under study except 'SML 668'. This also resulted in comparatively better HUE for seed yield in 'ML 1265' over other genotypes.

It may be concluded that July 5-25 seemed to be the best time of sowing for *kharif* mungbean under Punjab conditions. Genotype 'ML 1265' was superior to others both under timely and late sowings.

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