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Symbiotic efficiency, thermal requirement and yield of blackgram (*Vigna mungo*) genotypes as influenced by sowing time

GURIQBAL SINGH[1], HARPREET KAUR[2], NAVNEET AGGARWAL[3], HARI RAM[4], K K GILL[5] and VEENA KHANNA[6]

Punjab Agricultural University, Ludhiana, Punjab 141 004

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ABSTRACT

A field investigation was carried out during summer 2008, 2009 and 2010 at Research Farm of Punjab Agricultural University, Ludhiana, to study the performance of spring blackgram [*Vigna mungo* (L.) Hepper] genotypes (Sekhar 2, Pant U 19, Pant U 31, WBU 109, Mash 364 and Mash 1008) on different dates of sowing (10 March, 15 March, 20 March and 25 March). The grain yield recorded in 20 March sowing was significantly higher than the other sowing dates. Blackgram sown on 20 March registered 17.2, 3.2 and 4.5% higher grain yield over 10, 15 and 25 March sowing dates, respectively. Number of nodules was not significantly influenced by sowing dates. Nodule dry weight was significantly higher in 15, 20 and 25 March sowings than 10 March sowing. Early sown crop took more number of days to 50% flowering and maturity than late sown crop in 2008 but these were increased with delay in sowing in 2009 and 2010. Early sown crop required lower agroclimatic indices, i.e. growing degree days, heliothermal units, photothermal units than the late sown crop. Among genotypes, Mash 364 yielded the highest (1 136 kg/ha), closely followed by Mash 1008 (1 125 kg/ha), both being significantly superior to all other genotypes. The optimum time of sowing for spring blackgram was found to be 15-25 March and Mash 364 and Mash 1008 were the promising genotypes.

Key words: Blackgram, Genotypes, Sowing dates, Urdbean

Blackgram [*Vigna mungo* (L.) Hepper] also known as urdbean, is one of the important pulse crops in India. It is a protein-rich food which contains about 26% protein, almost three times that of cereals. Sowing time, a non-monetary input, is the single most important factor to obtain optimum yield. So determination of optimum sowing time for blackgram is inevitable. Optimum time of sowing of blackgram may vary from genotype to genotype. Therefore, there must be a specific sowing period during spring season for different genotypes to obtain maximum yield.

The rate of plant development for any genotype is directly related to temperature, so the length of time between the different stages will vary as the temperature varies, both between and within growing seasons. Changes in seasonal temperature affect the productivity through the changes in phenological development process of the crop. All the crops are vulnerable to different temperature stresses during the crop season and differential response of temperature change to various crops has been noticed under different production environments (Kalra *et al.* 2008). The occurrence of different phenological events during growing season of any crop and the effect of temperature on plant growth can be inferred using accumulated heat units or growing degree days. The present investigation was, therefore, undertaken to identify the suitable genotypes and sowing time of spring blackgram.

[1] Senior Agronomist (Pulses) (e mail: singhguriqbal@rediffmail.com), [2] Assistant Agronomist (Pulses) (e mail: hkmand@rediffmail.com), [3] Assistant Agronomist (Pulses) (e mail: navneetpulsespau@yahoo.com), [4] Wheat Agronomist (e mail: hr_saharan@yahoo.com), Department of Plant Breeding and Genetics; [5] Agrometeorologist (e mail: kgill2002@gmail.com), Department of Agricultural Meteorology; [6] Senior Microbiologist (e mail: veenadk@rediffmail.com), Department of Plant Breeding and Genetics

MATERIALS AND METHODS

A field experiment was conducted during spring season of 2008, 2009 and 2010 at the Research Farm of Punjab Agricultural University, Ludhiana (30° 56'N, 75° 52'E, altitude 247 m), India. The soil of the experimental site was loamy sand in texture. The experiment comprising four dates of sowing (10 March, 15 March, 20 March and 25 March) and six genotypes (Sekhar 2, Pant U 19, Pant U 31, WBU 109, Mash 364 and Mash 1008) was conducted in a split plot design by keeping dates of sowing in main plot and genotypes in sub-plot. The treatments were replicated four times in all

the years. The crop was sown in rows 22.5 cm apart using a seed rate of 50 kg/ha. Each plot measured 6.0 m × 1.35 m. The crop was raised as per the recommended package of practices (PAU 2008).

Nodulation data in terms of number and dry weight of nodules was recorded at 35 days after sowing (DAS). Five plants selected randomly were uprooted, washed and nodules detached carefully. After counting the total number of nodules, these were dried to constant weight at 60ºC for 48 hours and their weight was recorded.

Days taken to 50% flowering and maturity were recorded for each genotype under different dates of sowing. Growing degree days (GDD) were determined as per Nuttonson (1955):

$$GDD = \frac{Tmax+Tmin}{2} - T_b$$

where, Tmax, maximum temperature (ºC) during a day, Tmin, minimum temperature (ºC) during a day, T_b, base temperature of 10.0 ºC

Heliothermal units (HTU), the product of GDD and corresponding actual sunshine hours for that day, were computed on daily basis as follows:

$$HTU = GDD \times \text{Actual sunshine hours}$$

Photothermal units (PTU), the product of GDD and corresponding day length for that day, were computed on daily basis as follows:

$$PTU = GDD \times \text{Day length}$$

where, day length refers to maximum possible sunshine hours.

Table 1 Effect of dates of sowing and genotypes on different agroclimatic indices, i e GDD, HTU, PTU (°C day) and heat use efficiency (kg/ha/ºC day) of blackgram

Year	Treatment	50% flowering				Physiological maturity				
	Date of sowing/ Genotype	DAS	AGDD	AHTU	APTU	DAS	AGDD	AHTU	APTU	HUE
2008	10 March	50	738	7437	9325	79	1300	11518	16992	0.86
	15 March	49	750	7667	9583	76	1286	11509	16919	0.93
	20 March	47	759	7733	9781	75	1294	11513	17155	0.97
	25 March	46	781	7791	10166	72	1284	11325	17128	0.95
	Pant U 19	53	865	8650	11182	85	1489	11928	19863	0.78
	Pant U 31	46	720	7325	9223	74	1269	11431	16759	0.94
	Sekhar 2	49	772	7835	9917	74	1262	11526	16641	0.88
	WBU 109	49	767	7791	9845	76	1304	11783	17225	0.99
	Mash 364	44	665	6731	8478	69	1161	10643	15228	1.10
	Mash 1008	48	752	7608	9637	74	1258	11488	16574	0.89
2009	10 March	45	616	5899	7722	71	1147	10996	14891	0.65
	15 March	45	656	6329	8325	71	1221	11482	16012	0.79
	20 March	45	709	6751	9110	72	1281	12061	16963	0.87
	25 March	46	747	7070	9715	73	1357	12600	18159	0.80
	Pant U 19	46	707	6757	9063	72	1271	11928	16798	0.72
	Pant U 31	44	660	6323	8428	70	1217	11528	16036	0.67
	Sekhar 2	43	639	6124	8142	71	1232	11656	16231	0.61
	WBU 109	45	673	6430	8595	72	1243	11721	16391	0.68
	Mash 364	46	707	6720	9041	73	1272	11937	16791	0.98
	Mash 1008	46	707	6720	9041	73	1272	11937	16791	1.00
2010	10 March	38	647	6473	8054	72	1360	11267	17659	0.67
	15 March	39	704	6518	8883	72	1429	11785	18736	0.69
	20 March	42	797	6956	10199	73	1505	12489	19926	0.59
	25 March	42	828	6643	10722	73	1530	12624	20422	0.52
	Pant U 19	42	777	6849	9902	74	1492	12308	19694	0.65
	Pant U 31	42	735	6613	9348	74	1443	11979	19009	0.64
	Sekhar 2	39	726	6535	9231	72	1438	11908	18929	0.55
	WBU 109	39	727	6535	9231	72	1438	11908	18929	0.59
	Mash 364	39	721	6499	9160	72	1432	11832	18846	0.60
	Mash 1008	40	778	6854	9915	72	1494	12312	19708	0.68

Heat use efficiency (HUE) was calculated as follows:

$$HUE = \frac{\text{Grain yield (kg/ha)}}{\text{Accumulated heat units } (^{o}C \text{ day})}$$

Accumulated heat units are accumulated growing degree days, which a crop requires to attain a particular stage and also contributes towards yield in terms of grains as well as dry matter.

Growing degree days, heliothermal units and photothermal units were accumulated from the date of sowing to 50% flowering and maturity to give accumulated indices. Heat use efficiency was calculated at physiological maturity of the crop.

At maturity, data on plant height, branches/plant and pods/plant were recorded from randomly selected five plants from each plot; and seeds/pod were recorded from randomly selected 20 pods. Straw yield and grain yield were recorded on whole plot basis and converted into kg/ha. From the produce of each plot 100 seeds were taken for 100-seed weight data. Harvest index (HI) was also calculated. Pooled analysis of three-year data was done.

RESULTS AND DISCUSSION

Effect of date of sowing

During three years under study, during later part of the growing season, the weather conditions during 2009 and 2010 were almost similar as compared to 2008. During 2008, the number of days taken to 50% flowering and physiological maturity decreased with delay in sowing (Table 1). Temperature stress intensity is severe under late sowing, causing reduction in the duration of later growth phases, leading to acquisition of lesser days to mature (Mavi and Tupper 2005). Under Jabalpur (Madhya Pradesh) conditions the days to 50% flowering and maturity of blackgram decreased with delay in sowing summer season (Agrawal *et al.* 2004). However, during 2009 and 2010, the days taken to 50% flowering and physiological maturity increased with delay in sowings. This may be due to higher maximum and minimum temperatures prevailing during maturity period in 2009 and 2010 as compared to 2008. The crop acquired more sunshine hours in 2009 and 2010 than in 2008 mainly during the months of May and June, i e during reproductive period of the crop. The low temperatures and sunshine hours during 2008 may be due to the occurrence of more rainfall during the months of April and May. On the other hand, very low rainfall was received during 2009 and 2010 during these months. The high temperatures during 2009 and 2010 brought not much difference in maturity of crop sown at different dates during the month of March but lower temperatures during 2008 made the early March sown crop to took more days to mature as compared to late March sown crop.

Accumulated agroclimatic indices, i e growing degree days, heliothermal units, photothermal units and heat use efficiency computed for blackgram genotypes under different dates of sowing from sowing to 50% flowering and physiological maturity are given in Table 1. In general, early sown crop required lower agroclimatic indices as compared to late sown crop. The third and fourth dates of sowings accumulated more heat units, resulting in more heat use efficiencies than the first and second dates of sowings in 2008 and 2009 but not in 2010 when late sowings produced lower grain yields. Agroclimatic indices for various phenological stages are known to be influenced by sowing dates in summer blackgram (Agrawal *et al.* 2004).

The dates of sowing did not significantly affect the number of nodules/plant (Table 2). Nodule dry weight was influenced significantly by sowing dates. The three sowing dates of 15, 20 and 25 March were at par but significantly superior in nodule dry weight to 10 March sowing. The maximum plant height was recorded in 20 March sowing which was significantly higher than the other sowing dates. The maximum branches/plant was recorded in 15 March sowing which was, however, at par with 10 and 20 March sowings, all these three being significantly higher than 25 March sowing.

The 20 March sowing recorded the maximum pods/plant (21.1), which was significantly higher than all other dates of sowing (Table 3). Seeds/pod was at par in 10, 15 and 20 March sowings, which was significantly higher than 25 March sowing. The 100-seed weight was higher in 10 and 15 March sowings than in 20 and 25 March sowings. Kumar *et al*. (2008) reported that the maximum number of pods/plant, number of grains/pod and 100-grain weight were recorded under 20 March sown summer greengram. The sowing dates

Table 2 Symbiotic parameters (35 DAS) and plant growth characters (at harvest) of summer urdbean genotypes as influenced by sowing time (Pooled data of 2008, 2009 and 2010)

Treatment	No. of nodules/ plant	Nodules dry weight (mg/plant)	Plant height (cm)	Branches/ plant
Sowing date				
10 March	15.4	27.8	22.5	6.17
15 March	14.7	32.4	25.0	6.23
20 March	15.1	32.4	26.6	6.18
25 March	15.1	32.1	24.7	6.01
CD (*P*=0.05)	NS	2.6	1.0	0.10
Genotypes				
Pant U 19	14.0	29.6	23.0	6.06
Pant U 31	14.9	31.5	24.1	5.85
Sekhar 2	15.0	31.3	24.6	6.21
WBU 109	15.4	33.6	24.2	5.93
Mash 364	16.3	33.2	25.6	6.18
Mash 1008	13.9	28.2	26.6	6.65
CD (*P*=0.05)	1.1	2.5	0.61	0.15

Table 3 Yield attributes, yield and harvest index of summer blackgram genotypes as influenced by sowing time (Pooled data of 2008, 2009 and 2010)

Treatment	Pods/plant	Seeds/pod (g)	100-seed weight	Straw yield (kg/ha)	Grain yield (kg/ha)	Harvest index (%)
Sowing date						
10 March	17.9	5.95	4.45	3 870	922	24.9
15 March	19.5	5.90	4.46	4 124	1 047	25.6
20 March	21.1	5.86	4.39	3 959	1 081	25.6
25 March	18.6	5.71	4.33	3 742	1 034	25.3
CD (*P*=0.05)	0.61	0.11	0.04	84	30	NS
Genotypes						
Pant U 19	18.7	6.17	3.95	3 594	982	26.8
Pant U 31	20.0	5.85	4.61	3 476	878	26.6
Sekhar 2	18.7	6.08	5.12	4 100	1 012	26.2
WBU 109	18.3	5.62	4.04	3 692	992	26.0
Mash 364	19.9	5.83	4.48	4 413	1 136	22.8
Mash 1008	20.1	5.59	4.26	4 268	1 125	23.8
CD (*P*=0.05)	0.54	0.10	0.05	139	32	1.16

significantly influenced the grain yield. The grain yield was highest in 20 March sown crop, which was significantly higher than in other sowing dates. Similar findings have been reported by Kumar *et al*. (2007) in spring blackgram. Blackgram sown on 20 March registered 17.2, 3.2 and 4.5% higher grain yield over 10, 15 and 25 March sowings, respectively. Sowing dates may influence the grain yields not only by their effect on growth and yield attributes but also on incidence of diseases (Dubey and Singh 2006). Straw yield was highest in 15 March sowing , followed by 20 March sowing. Harvest index was not influenced significantly by sowing dates.

Performance of genotypes

Genotypes varied in days to 50% flowering and maturity (Table 1). Variation in flowering and maturity time among genotypes is mainly governed by the genetic make up of the genotype (Miah *et al*. 2009). Genotypes differed not only in agroclimatic indices to attain physiological maturity but also in terms of heat-use efficiency for grain yield. A significant polynomial relationships were observed between grain yield and growing degree days (R^2 = 0.45) (Fig 1) and grain yield and heat-use efficiency (R^2 = 0.75) (Fig 2). Therefore, the equations given in Fig 1 and 2 can be a useful tool in predicting growth behavior of blackgram genotypes.

Genotypes differed significantly in nodule number as well as in nodule dry weight (Table 2). The higher number and dry weight of nodules was recorded with genotypes Mash 364 and WBU 109 and, therefore, with regards to the symbiotic efficiency, these two genotypes had an edge over the others. Mash 1008 attained the maximum height, followed by Mash 364. Mash 1008 recorded significantly higher branches/plant than the other genotypes.

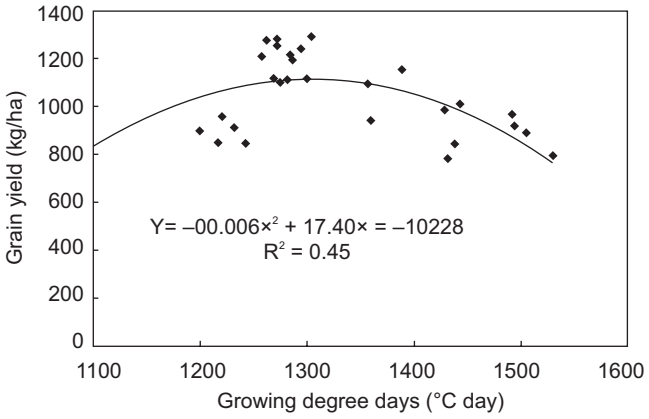

Fig 1 Relationship between accumulated growing degree days and grain yield in blackgram genotypes during three consecutive crop seasons

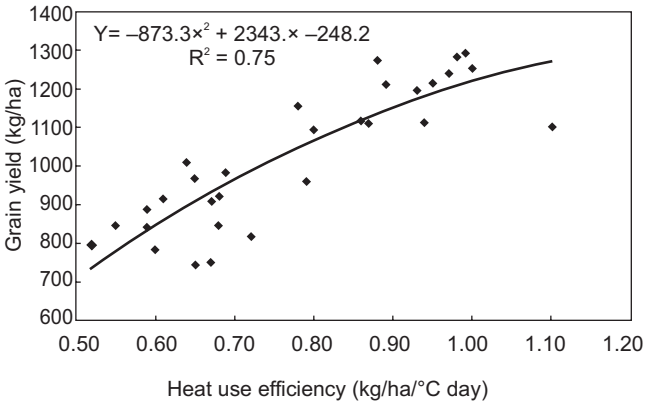

Fig 2 Relationship between heat use efficiency and grain yield in blackgram genotypes during three consecutive crop seasons

Table 4 Interaction effect of sowing dates and genotypes on the grain yield of summer blackgram in 2008, 2009 and 2010

Sowing date	Grain yield (kg/ha)					
	Genotypes					
	Pant U 19	Pant U 31	Sekhar 2	WBU 109	Mash 364	Mash 1008
2008						
10 March	1125	1000	1181	1167	986	1236
15 March	1236	1083	1125	1278	1181	1278
20 March	1292	1139	1181	1388	1167	1277
25 March	1189	1194	1133	1333	1131	1306
2009						
10 March	700	622	778	700	797	856
15 March	778	661	933	894	1167	1322
20 March	933	778	1011	972	1536	1439
25 March	856	933	938	817	1633	1400
2010						
10 March	922	822	944	937	977	855
15 March	955	777	1137	897	1177	966
20 March	955	800	955	822	966	844
25 March	848	733	835	704	922	722
	2008	*2009*	*2010*			
CD (*P*=0.05)	NS	148	75			

The highest pods/plant was in Mash 1008, seeds/pod in Pant U 19 and 100-seed weight in Sekhar 2 (Table 3). The effect of genotypes on grain yield was significant. Mash 364 recorded highest grain yield, closely followed by Mash 1008, both being significantly superior to the other genotypes. Kumar *et al.* (2007) and Verma *et al.* (2011) also reported genotypic variation with respect to plant growth and grain yield in blackgram.

Interaction effect

Interaction effect between date of sowing and genotypes with respect to grain yield during 2008 was found to be non-significant, whereas it was found to be significant during 2009 and 2010 (Table 4). In 2009, grain yield of Mash 364 was significantly higher in 25 March sowing than the other genotypes, whereas in 20 March sowing the grain yield of Mash 364 genotype was at par with Mash 1008 and significantly higher than the other genotypes. However, Mash 1008 in 15 March sowing significantly outyielded the other genotypes. The grain yield of all the genotypes was reduced drastically in 10 March sowing. In 2010, Mash 364 recorded the maximum grain yield in 15 March sowing which was significantly higher than all other genotypes and statistically at par with Sekhar 2, sown at different sowing dates.

From this three-year study it can be concluded that under Punjab conditions the optimum time of sowing for spring blackgram is 15-25 March and Mash 364 and Mash 1008 are the promising genotypes.

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