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Evaluation of blackgram genotypes (*Vigna mungo*) under maize based intercropping systems

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Blackgram (*Vigna mungo* L.) is one of the most important *kharif* pulses. It has the potential to contribute on a large scale to the pulse production in India as it can be grown in many intercropping systems because it is a fast growing short statured legume crop with short duration. Blackgram is grown on an area of 3.25 million hectares with production of 1.5 million tonnes and yield of 400 kg/ha in the country (Anonymous 2016a). In Himachal Pradesh, it is also one of the important pulses, mostly grown as an intercrop with maize. It is grown on an area of 0.0079 million hectares with production of 0.0036 million tonnes and yield of 449 kg/ha (Anonymous 2016b). Since the present and future aspects of bringing more area under pulses appear no brighter, spatial and or temporal intensification of cropping, particularly intercropping provides an alternative of immense relevance and potential. Maize is the main *kharif* cereal in the state. The area under maize cultivation in the state is 0.294 million hectares with a total production and productivity of 0.737 million tonnes and 25.1 q/ha, respectively (Anonymous 2016c). Maize is a heavy feeder crop responding favorably to fertilization, especially where soils are generally low in native fertility. Hybrid maize needs higher dose of nitrogen in addition to phosphorus and potassium. Most of the old varieties of blackgram have become susceptible to high rainfall and higher dose of nitrogen resulting in poor crop yield in mid-hill region of Himachal Pradesh. Considering the above said facts, the present investigation was carried out to evaluate the performance of promising genotypes of blackgram under maize + blackgram intercropping system at different levels of nitrogen.

The field experiment was conducted during *Kharif* 2017 at Agronomy Research Farm, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at 32°6'N latitude, 76°3'E longitude and at an altitude of 1290.8 m amsl. The experiment was laid out in a randomized block design comprising 5 genotypes (Him mash-1, DKU-98, DKU-99, DKU-118 and DKU-82) and two nitrogen levels (50 and 100% recommended dose of nitrogen). Each treatment allocated randomly in each plot using random table and replicated thrice. The soil of the experimental site was silty clay loam with *p*H 5.7, 0.56% OC, 132.63 kg/ha available nitrogen, 14.67 kg/ha available phosphorus and 268 kg/ha available potassium. Soil samples from 0–15 cm depth were collected randomly from all the plots (36) before starting the experiment and a composite soil sample was prepared, which was dried, ground and sieved through 2 mm sieve and then replicated samples were analyzed for different physicochemical properties. Mechanical analysis, *p*H, organic carbon, available nitrogen, available phosphorus and available potassium were analyzed by International pipette method, Glass electrode meter, Walkley and Black's rapid titration method, Alkaline permanganate method, 0.5 $NaHCO_3$ extractant and Neutral normal ammonium acetate extraction method, respectively. During the crop season, the weekly maximum and minimum temperature ranged from 25.2–29.9°C and 11.6–20.8°C, respectively. The mean relative humidity ranged from 50.6 to 95.3% and total 2340.2 mm rainfall was received during the crop season. Seeds were treated with Bavistin @2.5 g/kg seed before sowing for the protection of crop plants from seed borne diseases. Maize crop was sown at 60 cm and 20 cm inter and intra row spacing, respectively, while blackgram genotypes were sown in between two rows of maize as intercrop. Phosphorus and potassium were applied at the rate of 60 kg P_2O_5 and 40 kg K_2O/ha while nitrogen was applied as per treatments, 100 and 50% of recommended dose of nitrogen (120 kg/ha) to maize crop. Other package of practices recommended for the region was also followed. Data were recorded on growth, yield attributes and yields and subjected to analysis of variance with mean comparison of 5% level of significance.

Plant height of different blackgram genotypes intercropped with maize was significantly affected at 30, 90

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days after sowing and at harvest (Table 1). Significantly taller plants were recorded in Him mash-1 genotype. Different nitrogen levels significantly affected plant height at all the growth stages. Significantly taller plants of blackgram were recorded at 100% recommended dose of nitrogen than 50% recommended dose of nitrogen applied to maize. It is presumed that the nitrogen dose favorably influenced the plant metabolic activities and finally resulted in improved growth, development and productivity of blackgram. These findings are in close conformity with those of Kheroar and Patra (2014), Manasa *et al*. (2018). Sole blackgram significantly recorded taller plants than intercropped blackgram at all the growth stages. This may be due to balanced nutrition to sole blackgram than that of intercrop blackgram. Interaction effect of blackgram genotypes and nitrogen levels was recorded at 30 and 60 days after sowing. Significantly taller plants were recorded in Him Mash-1 × N_{100} followed by DKU-98 × N_{100} .

Dry matter accumulation per plant of different genotypes was significantly affected under intercropping with maize at all the growth stages. Higher dry matter accumulation per plant was recorded in Him mash-1. Dry matter increased progressively under advance in age of the crop up to harvest. Higher dry matter per plant was recorded at 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram recorded significantly higher dry matter at all the growth stages than intercropped blackgram (Table 1). This may be attributed to the fact that dry matter accumulation is the function of plant height and number of leaves per plant. More uptake of nitrogen leads to more dry matter accumulation of plant. Similar results were observed by Polthanee *et al.* (2003). Interaction effect of blackgram genotypes and nitrogen levels was recorded at 30 days after sowing and at harvest. Him Mash -1 × N_{100} followed by DKU-99× N_{100} resulted in higher dry matter accumulation per plant at 30 days after sowing and at harvest. Significantly lower dry matter of blackgram was recorded with DKU-98 × N_{50}. Number of nodules per plant remained unaffected due to different blackgram genotypes and nitrogen levels. Significant difference was observed in sole and intercropped blackgram. Sole blackgram significantly recorded higher number of nodules per plant than intercropped blackgram. Interaction effect also remained unaffected.

Crop growth rate significantly differed at 30 and 90 days after sowing. Significantly higher crop growth rate was recorded in Him mash-1 at 30 days after sowing. DKU-82 significantly recorded higher crop growth rate at harvest which was at par with Him mash-1, DKU-98 and DKU-99. Higher crop growth rate was recorded with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen (Table 1). Sole blackgram recorded significantly higher crop growth rate than intercropped blackgram. Interaction effect of blackgram genotypes and nitrogen levels significantly affected the crop growth rate at 30 and 60 days after sowing. Him mash-1× N_{100} resulted in higher crop growth rate of intercropped blackgram which was at par with DKU-118× N_{100} and DKU-99 × N_{100} at 30 days after sowing and at harvest.

Relative growth rate of blackgram genotypes was also significantly affected at all the growth stages and the highest relative growth rate was recorded in Him mash-1 at 30 and 60 days after sowing. DKU-82 and DKU-99 significantly recorded higher relative growth rate at harvest (Table 1). Relative growth rate was significantly affected by different nitrogen levels at 30 and 60 days after sowing. Significantly higher relative growth rate was recorded with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram significantly recorded higher relative growth rate than intercropped blackgram at 30 and 60 days after sowing. Interaction effect of blackgram genotypes and nitrogen levels was found to be non-significant.

Yield attributes of different genotypes were significantly affected by different treatments. Higher number of primary branches per plant was recorded in Him mash-1 followed by DKU-118, DKU-82 and DKU-99. Significantly higher number of branches per plant was recorded with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram resulted in higher number of primary branches per plant than intercropped blackgram. Interaction effect of blackgram genotypes and nitrogen levels was recorded to be significant. Him mash-1 × N_{100} followed by DKU-118 × N_{100} recorded higher number of primary branches per plant.

Significantly higher number of pods per plant was recorded in Him mash-1followed by DKU-82. The treatment, 100% recommended dose of nitrogen recorded significantly higher number of pods per plant (Table 2). Application of higher doses of nitrogen did not show any adverse effect on blackgram since the application of fertilizer doses were restricted to maize rows only. Similar results were observed by Srivastava and Srivastava (1993), Kheroar and Patra (2014), Manasa *et al*. (2018). Sole blackgram resulted in higher number of pods per plant than intercropped blackgram. This may be due to sufficient availability of nutrients to sole crop than intercrop. Significant interaction effect of blackgram genotypes and nitrogen levels was recorded. Him mash-1× N_{100} followed by DKU-118 × N_{100} recorded significantly higher number of pods per plant.

Higher number of seeds per pod was recorded in Him mash-1 followed by DKU-99. Significantly, higher number of seeds per pod was recorded with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram and intercropped blackgram remained unaffected in respect of number of seeds per pod. However, Sole blackgram recorded numerically higher number of seeds per pod than intercropped blackgram (Table 2). Interaction effect of blackgram genotypes and nitrogen levels was recorded to be significant. Him Mash-1× N_{100} recorded higher number of seeds per pod followed by DKU-99 × N_{100}, DKU-82 × N_{100} and DKU-98 × N_{100}. The treatment 100% recommended dose of nitrogen significantly resulted in higher test weight. Sole blackgram recorded higher test weight than intercropped blackgram (Table 2). Significant

Table 1 Plant height, dry matter accumulation, nodules per plant, crop and relative growth rate of blackgram under maize + blackgram intercropping system

Treatment	Plant height (cm)			No. of nodules/ plant	Dry matter accumulation (g/plant)			Crop growth rate (g/plant/day)			Relative growth rate (g/g/day)		
	30 DAS	60 DAS	Harvest		30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Blackgram genotype													
Him Mash -1	26.5	50.5	53.0	24.7	3.0	10.6	28.1	0.102	0.252	0.583	0.016	0.034	0.014
DKU-118	25.2	50.0	52.5	22.9	2.7	10.3	26.1	0.089	0.254	0.525	0.014	0.033	0.013
DKU-82	24.9	48.4	49.8	23.3	2.0	8.9	26.7	0.068	0.230	0.594	0.010	0.031	0.016
DKU-98	26.9	48.7	50.5	22.8	1.6	8.6	25.6	0.052	0.234	0.568	0.006	0.031	0.016
DKU-99	23.7	47.6	49.4	20.8	2.4	10.2	27.6	0.080	0.260	0.582	0.012	0.033	0.001
SEm±	0.44	0.45	0.66	1.00	0.09	0.20	0.21	0.0031	0.0084	0.0098	0.0005	0.0003	0.0003
CD (P=0.05)	1.29	1.32	1.94	NS	0.28	0.59	0.63	0.0092	NS	0.0289	0.0014	0.0008	0.0009
Nitrogen levels (% RDN)													
50	22.7	45.9	47.6	22.2	2.0	9.2	26.0	0.066	0.242	0.559	0.009	0.032	0.015
100	28.3	52.2	54.5	23.6	2.7	10.2	27.7	0.091	0.249	0.581	0.014	0.033	0.015
SEm±	0.28	0.28	0.42	0.63	0.06	0.13	0.14	0.0019	0.0053	0.0062	0.0003	0.0002	0.0002
CD (P=0.05)	0.82	0.83	1.23	NS	0.18	0.37	0.40	0.0058	NS	0.0183	0.0009	0.0005	NS
Sole blackgram vs Intercrop blackgram													
Sole	32.51	57.80	59.56	26.6	3.4	11.3	29.5	0.1134	0.264	0.606	0.018	0.035	0.014
Intercrop	25.47	49.07	51.05	22.9	2.4	9.7	26.8	0.0783	0.246	0.570	0.012	0.032	0.015
SEm±	0.65	0.66	0.97	1.47	0.14	0.30	0.32	0.0046	0.0124	0.014	0.0007	0.0004	0.0004
CD (P=0.05)	1.87	1.91	2.81	4.26	0.40	0.86	0.92	0.1778	NS	0.0419	0.0020	0.0012	NS

RDN, Recommended dose of nitrogen; DAS, Days after sowing.

Table 2 Yield attributes and yields of blackgram under maize + blackgram intercropping system

Treatment	Yield attributes				Yield (kg/ha)		Harvest index (%)
	No. of primary branches/plant	No. of pods/ plant	No. of seeds/ pod	Test weight (g)	Grain	Stover	
Blackgram genotype							
Him Mash -1	9.2	22.2	6.7	44.2	240.5	1217.8	16.5
DKU-118	9.9	19.9	6.4	39.7	217.8	1090.9	16.6
DKU-82	9.4	23.3	6.3	42.7	227.3	1130.7	16.7
DKU-98	8.8	18.0	5.7	43.4	219.7	1100.4	16.6
DKU-99	9.4	19.7	6.7	43.7	231.1	1153.4	16.7
SEm±	0.24	0.46	0.23	0.08	6.67	30.87	0.45
CD (P=0.05)	0.71	1.37	0.69	0.23	NS	NS	NS
Nitrogen levels (% RDN)							
50	8.8	18.6	6.1	41.7	200.8	1048.5	16.06
100	9.9	22.6	6.7	43.8	253.8	1228.8	17.17
SEm±	0.15	0.29	0.15	0.05	4.22	19.52	0.28
CD (P=0.05)	0.45	0.87	0.43	0.14	12.45	57.59	0.83
Sole blackgram vs Intercrop blackgram							
Sole	10.6	22.5	7	46.6	1113.6	3784.0	22.7
Intercrop	9.32	20.62	6.36	42.7	227.2	1138.6	16.6
SEm±	0.36	0.68	0.34	0.11	9.8	45.5	0.6
CD (P=0.05)	1.03	1.98	NS	0.33	28.5	131.9	1.9

RDN, Recommended dose of nitrogen.

interaction effect of blackgram genotypes and nitrogen levels was recorded. Him Mash-1 × N_{100} recorded the highest test weight.

Grain and straw yield of blackgram genotypes remained unaffected under maize + blackgram intercropping system. However, numerically higher grain and straw yields were recorded in Him mash-1 (Table 1). Nitrogen levels significantly affected the grain and straw yields. The highest grain and straw yields were recorded with 100% recommended dose of nitrogen. Similar results were also reported by Naik *et al.* (2017). The increase in yields of maize + legume intercropping should be attributed to combined effect of nitrogen as well as complementary effect of legume association with maize. Similar findings were observed by Kheroar and Patra (2014), Manasa *et al*. (2018). Sole blackgram recorded significantly higher grain yield than intercropped blackgram. The lower yield under intercropping system was due to low plant stand as compared to sole crop of blackgram. Interaction effect of blackgram genotypes and nitrogen levels was found to be non-significant in respect of grain yield. Harvest index of blackgram genotypes was significantly affected by different nitrogen levels. Significantly higher harvest index was recorded with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram recorded higher harvest index than intercropped blackgram. Interaction effect of blackgram genotypes and nitrogen levels did not affect the harvest index of blackgram.

SUMMARY

A field experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during rainy season of 2017, to evaluate the performance of blackgram genotypes under maize + blackgram intercropping system with different levels of nitrogen. The experiment was laid out in randomized block design comprising of 5 genotypes (Him mash-1, DKU-118, DKU-82, DKU-98 and DKU-99) and two nitrogen levels (50 and 100% recommended dose of nitrogen). Experimental soil was silty clay loam in texture, acidic in reaction, low in available nitrogen, and medium in available phosphorus and potassium. Him mash-1 genotype showed significantly higher plant height, dry matter accumulation, relative growth rate, seeds per pod (6.7) and grain yield (240.5 kg/ha). The treatment, 100% recommended dose of nitrogen resulted in improved growth and higher primary branches per plant (9.9), pods per plant (22.6), seeds per pod (6.7), test weight (43.8 g) and grain yield (253.8 kg/ha). Him mash-1showed the best performance with 100% recommended dose of nitrogen applied to maize under maize + blackgram intercropping system in mid-hill region of Himachal Pradesh.

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