

Research Article

Field assessment of blackgram (*Vigna mungo* L. Hepper) genotypes against major insect pests in subtropical region of Nepal

Saraswati Neupane^{1*}, Subash Subedi¹, Rajendra Darai² and Trista Sharma³

¹National Maize Research Program, Rampur, Chitwan, Nepal

²Grain Legumes Research Program, Khajura, Banke, Nepal

³Nepal Polytechnic Institute, Bharatpur, Chitwan, Nepal

* Correspondence: sarusanu2017@gmail.com

*ORCID: <https://orcid.org/0000-0003-3033-5840>

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ABSTRACT

Direct damage due to insect pests is one of the major causes limiting the yield potential of blackgram (*Vigna mungo* L. Hepper) in Nepal. A total of 17 blackgram genotypes were screened for resistance to major insect pests, including aphid (*Aphis craccivora* Koch.), whitefly (*Bemisia tabaci* Genn.), hairy caterpillar (*Spilosoma obliqua* Walker) and pod borer (*Helicoverpa armigera* Hubner) in National Maize Research Program, Rampur, Chitwan during summer season of 2018 and 2019. The design of the experiment was randomized complete block having three replications. Genotypes were sown on first week of August in a unit plot size of 4 rows of 2 m long with 40 cm row to row spacing and continue plant to plant spacing was maintained and net harvested plot was 3.2 square meters. The recommended dose of fertilizer was 20:40:20 N:P₂O₅:K₂O kg/ha and seed rate 25 kg/ha. The package of agronomic practices was followed as per national recommendation. Data on insects were collected by counting the number of insects per plant. The yield and yield components were recorded at harvest. All screened genotypes differed significantly ($p < 0.05$) for insect population, yield and yield components. From two years field data, three genotypes BLG0069-1, BLG0036-1 and BLG0079-1 had lower number of above mentioned insect populations, exhibited more resistant in both years and produced higher grain yield (~1.5 t/ha) than other genotypes. These genotypes might be useful for the development of major insect pest tolerant high yielding blackgram variety in subtropical region of Nepal.

Keywords: Blackgram, insect pests, resistance, screening

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INTRODUCTION

Black gram (*Vigna mungo* L. Hepper) is the second most important pulse crop in Nepal in terms of area (23,492 ha) after lentil and third in production (19,928 mt) after lentil and soybean with a productivity of 848 kg/ha (MoAD, 2019). This crop is cultivated, particularly during the summer season as a short duration crop, over a wide range of agro-climatic conditions in different regions of Nepal (Gharti *et al.*, 2014). The productivity of black gram is very low in

Nepal and one of the major region for low productivity is likely to be attacked by a complex of insect pests like sucking, defoliators and pod borers at different stages of the crop (Neupane *et al.*, 2016). The sucking insect pests like aphid (*Aphis craccivora* Koch.) and whitefly (*Bemisia tabaci* Genn.) are important pests during early stages of crop growth which not only reduces the plant vigor but also acts as vectors for viral diseases in blackgram (Subedi *et al.*, 2016). Defoliators like hairy caterpillar (*Spilosoma obliqua* Walker) and pod borer (*Helicoverpa armigera* Hubner) were other major pests during vegetative to pod maturing stage of the crop, causing yield loss in blackgram (GLRP, 2012). The annual yield loss of blackgram due to the major insect pests has been estimated about 15 to 20 percent in Nepal (GLRP, 2015). Farmers were unable to control blackgram insect pests with regular spraying of conventional insecticides, which resulted in contamination of natural resources and also increased pesticidal resistance. Excessive use of insecticides may lead to serious problems such as pesticidal pollution, mortality of natural enemies and pollinators (Miller, 2004). Hence there is need and big scope for host plant resistance which is a primary component to fight against the insect pest throughout the crop stage and ultimately development of resistant varieties. The broader spectrum of genetic resistance in insect management strategy helps reduce the use of pesticides, reduce production costs and mitigate damage to human health and environment. The objective of this research was to evaluate the blackgram genotypes against major insect pests considering grain yield management and to increase the productivity.

MATERIALS AND METHODS

Field screening technique was used to evaluate crop resistance to major pests (GLRP, 2015), *i.e.* aphid, whitefly, hairy caterpillar and pod borer in blackgram at National Maize Research Program, Rampur, Chitwan during summer season of 2018 and 2019. The latitude, longitude and altitude of the experimental site were 27° 40'N, 84° 19' E, and 228 masl respectively. A total of 17 blackgram genotypes were screened following randomized complete block design with three replications. Genotypes were sown on first week of August in a unit plot size of 4 rows of 2 m long with 40 cm row to row spacing and continue plant to plant spacing was maintained and net harvested plot was 3.2 square meters. The recommended dose of fertilizer was 20:40:20 N:P₂O₅:K₂O kg/ha and seed rate 25 kg/ha. The package of agronomic practices was followed as per national recommendation (GLRP, 2015). Data on insects were collected by counting the number of insects per plant. The yield and yield components like days to flowering, days to maturity, plant height, pod per plant, seed per pod and hundred seed weight (HSWt) were recorded at harvest. The data was recorded on ten randomly selected plants from each genotype. Data were analyzed statistically by performing analysis of variance (Steel & Torrie, 1980) using Microsoft Excel and GenStat software (18th edition). The relation between grain yield and insect populations were calculated. All insect data were subjected to logarithmic transformation before statistical analysis (Gomez & Gomez, 1984; Shrestha *et al.*, 2019).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant ($P < 0.01$) differences among the seventeen genotypes for all the recorded traits except seed per pod during the summer season of 2018 and 2019 (Table 1 and 2). It also showed within range of co-efficient of variation for all the traits. The flowering days was found earlier (37.84 ± 0.33 days) in FY 2018 (Table 1) while genotypes matured early (55.75 ± 0.35 days) in FY 2019 (Table 2). The average plant height reached up to 61.61 ± 0.52 cm in 2019 (Table 2) while it was just 35.39 ± 0.73 cm in 2018 (Table 1). The

number of pods per plant (42.57 ± 1.39), hundred seed weight (5.16 ± 0.13 g) and grain yield (1246.36 ± 47.02 kg/ha) was recorded higher in FY 2018 (Table 1). The mean grain yield was 1112.56 ± 36.51 kg/ha in FY 2019 (Table 2).

Table 1. Statistics of blackgram genotypes for the traits recorded during FY 2018 at Rampur, Chitwan, Nepal

Traits	Mean \pm SEM	Range	F test	LSD (0.05)	CV,%
Days to flowering	$^{\dagger}37.84 \pm 0.33$	31.00 - 43.00	**	1.86	3.00
Days to maturity	63.00 ± 0.76	50.00 - 75.00	**	2.35	2.20
Plant height (cm)	35.39 ± 0.73	27.60 - 48.00	**	2.78	4.70
Pod/plant	42.57 ± 1.39	5.00 - 67.00	**	7.47	10.60
Seed/pod	4.68 ± 0.10	3.83 - 6.00	NS	0.93	12.00
Hundred seed weight (g)	5.16 ± 0.13	3.35 - 6.73	**	0.33	3.90
Grain Yield (kg/ha)	1246.36 ± 47.02	562.00 - 2030.00	**	209.60	10.10
Aphid /plant	28.00 ± 3.09 (1.29 ± 0.06)	1.75 - 78.50 (0.24-1.89)	**	0.05	2.40
Whitefly/plant	28.06 ± 1.69 (1.39 ± 0.04)	4.25 - 52.25 (0.63-1.72)	**	0.04	1.90
Hairy caterpillar /plant	46.51 ± 3.08 (1.60 ± 0.04)	8.50 - 95.00 (0.93-1.98)	**	0.04	1.60
Pod borer /plant	10.33 ± 0.49 (0.98 ± 0.03)	2.00 - 16.00 (0.30-1.20)	**	0.09	5.70

*[†]means of three replications, value in parenthesis indicate log transformed value **- significant at ≤ 0.01 p level, NS- Non significant, SEM- standard error mean, CV- coefficient of variation, cm- centimeter, %- percentage, g- gram, kg/ha- kilogram per hectare*

Table 2. Statistics of blackgram genotypes for the traits recorded during FY 2019 at Rampur, Chitwan, Nepal

Traits	Mean \pm SEM	Range	F test	LSD (0.05)	CV,%
Days to flowering	$^{\dagger}39.16 \pm 0.55$	32.00 - 48.00	**	3.75	5.80
Days to maturity	55.75 ± 0.35	51.00 - 60.00	**	1.32	1.40
Plant height (cm)	61.61 ± 0.52	56.00 - 71.40	**	1.89	1.80
Pod/plant	18.09 ± 0.53	12.40 - 28.80	**	1.56	5.20
Seed/pod	6.32 ± 0.04	5.70 - 6.90	NS	0.45	4.30
Hundred seed weight (g)	4.17 ± 0.07	3.27 - 4.95	**	0.49	7.10
Grain Yield (kg/ha)	1112.56 ± 36.51	468.75 - 1662.50	**	99.76	5.40
Aphid /plant	36.75 ± 5.22 (1.37 ± 0.06)	2.50 - 137.25 (0.40 - 2.14)	**	0.07	3.20
Whitefly/plant	34.06 ± 2.10 (1.47 ± 0.04)	5.00 - 65.50 (0.70-1.82)	**	0.05	2.10
Hairy caterpillar /plant	44.72 ± 4.43 (1.54 ± 0.05)	4.00 - 123.25 (0.60-2.09)	**	0.06	2.40
Pod borer /plant	8.57 ± 0.46 (0.90 ± 0.03)	1.50 - 18.50 (0.18-1.27)	**	0.10	7.00

*[†]means of three replications, value in parenthesis indicate log transformed value **- significant at ≤ 0.01 p level, NS- Non significant, SEM- standard error mean, CV- coefficient of variation, cm- centimeter, %- percentage, g- gram, kg/ha- kilogram per hectare*

The population of sucking pests like aphid and whitefly was comparatively higher in FY 2019 while average count was higher for defoliator like hairy caterpillar and pod borer in FY 2018 (Table 1 and 2). The population of aphid per plant was recorded up to 78.50 from 1.75 with the mean of 28 ± 3.09 in 2018 (Table 1) while it reached up to 137.25 from 2.50 per plant with the mean value of 36.75 ± 5.22 in 2019 (Table 2). The number of whitefly per plant was ranged from 4.25 to 52.25 with the mean of 28.06 ± 1.69 in 2018 (Table 1) while it ranged from 5 to 65.5 with the mean of 34.06 ± 2.10 in 2019 (Table 2). The maximum number of hairy caterpillar per plant was recorded up to 123.25 ranged from 4 per plant with the mean of 44.72 ± 4.43 per plant in 2019 (Table 2) while in 2018, the average count of hairy caterpillar per plant was 46.51 ± 3.08 and ranged from 8.5 to 95 per plant (Table 1). The average number pod borer per plant (10.33 ± 0.49) was higher in FY 2018 (Table 1) and ranged 2 to 16 per plant while its population was reached up to 18.50 from 1.50 per plant with the mean of 8.57 ± 0.46 per plant in FY 2019 (Table 2).

Table 3. Combined mean performance of blackgram genotypes to the yield and yield attributing components during 2018-2019 at Rampur, Chitwan, Nepal

Genotypes	FD	MD	PH (cm)	P/P	S/P	HSW (g)	GY (kg/ha)
BLG0067-1	†35.50	58.00	44.40	30.60	5.36	3.99	1132.00
BLG0066-1-1	39.17	60.83	45.20	36.50	5.37	3.74	1088.42
BLG0092-1	40.00	57.50	47.27	23.33	5.44	3.84	1108.75
BLG0061-2-2	36.17	58.50	47.10	30.97	5.19	4.92	1256.83
BLG0072-1	38.83	57.00	44.20	28.57	5.79	4.05	1225.96
BLG0035-1	40.00	60.67	50.63	33.30	5.55	5.10	1284.17
BLG0068-2	38.50	58.00	47.57	28.30	5.52	4.93	1150.00
BLG0095-1-1	41.17	58.50	51.43	30.97	5.67	4.84	819.15
BLG0076-2	41.50	58.67	46.70	32.93	5.52	4.43	1106.24
BLG0041-1	37.50	59.33	54.10	30.30	5.81	5.23	1122.25
BLG0069-1	33.67	53.17	46.00	42.80	5.27	5.12	1818.29
BLG0024-1-2	41.83	62.17	52.73	28.10	5.30	4.82	1149.92
BLG0003-2-1	39.50	60.17	45.23	26.70	5.42	4.29	1024.88
BLG0036-1	37.00	64.17	53.23	30.30	5.25	5.18	1500.33
Sekhar-1	35.67	56.67	53.90	31.03	5.88	5.39	1210.48
BLG0079-1	36.67	60.33	46.63	28.13	5.52	5.41	1530.21
Local check	41.83	65.67	48.13	22.80	5.62	4.02	522.96
Grand Mean	38.50	59.37	48.50	30.33	5.50	4.67	1179.46
F test (Genotype)	**	**	**	**	NS	**	**
F test (Genotype × Year)	**	**	**	**	NS	**	**
LSD (0.05)	2.05	1.45	1.71	3.77	-	0.29	112.26
CV, %	4.6	2.1	3.1	10.8	9.4	5.3	8.3

†means of three replications, value in parenthesis indicate log transformed value **- significant at ≤ 0.01 p level, NS- Non significant, FD-days to flowering, MD- days to maturity, PH-plant height, P/P-pod per plant, S/P-seed per pod, HSW-hundred seed weight, GY-grain yield, cm- centimeter, g-gram, kg/ha- kilogram per hectare

The various yield attributing parameters like days to flowering, days to maturity, plant height, pod per plant, hundred seed weight and grain yield were significantly varied ($P \leq 0.01$) among the tested blackgram genotypes (Table 3). Genotype BLG0069-1 have early flowering (33.67 days) and maturity days (53.17 days) with higher number of pod per plant (42.80) and higher grain yield (1818.29 kg/ha) compared to other genotypes. The plant height ranged from 44.2 to 54.1 cm and the higher plant height (54.1 cm) was recorded with BLG0041-1. The hundred seed weight was ranged from 3.74 to 5.41 g and the higher weight (5.41 g) was recorded in BLG0079-1 (Table 3). The delayed flowering (41.83 days) and maturity days (65.67 days) with lower no. of pod per plant (22.80) and lower grain yield (522.96 kg/ha) was recorded in local check (Table 3).

Table 4. Combined mean performance of blackgram genotypes to the major insect pests recorded during 2018-2019 at Rampur, Chitwan, Nepal

Genotypes	Aphid/plant	Whitefly/plant	Hairy caterpillar/plant	Pod borer/plant
BLG 0067-1	†19.54 (1.29)	24.50 (1.39)	35.83 (1.55)	7.58 (0.87)
BLG 0066-1-1	25.38 (1.40)	32.29 (1.51)	38.67 (1.58)	11.50 (1.05)
BLG 0092-1	25.71 (1.41)	27.79 (1.44)	46.63 (1.67)	9.17 (0.96)
BLG0061-2-2	12.92 (1.08)	34.25 (1.53)	47.33 (1.67)	11.25 (1.03)
BLG0072-1	21.29 (1.30)	30.21 (1.47)	47.96 (1.68)	9.83 (0.98)
BLG0035-1	17.33 (1.22)	28.71 (1.46)	41.50 (1.60)	9.83 (0.97)
BLG0068-2	31.58 (1.49)	35.75 (1.55)	44.83 (1.65)	10.00 (0.99)
BLG0095-1-1	87.08 (1.92)	49.17 (1.69)	90.83 (1.95)	12.67 (1.10)
BLG0076-2	29.42 (1.45)	34.38 (1.53)	45.38 (1.64)	10.58 (1.01)
BLG0041-1	52.88 (1.64)	41.33 (1.60)	63.67 (1.76)	10.67 (1.03)
BLG0069-1	2.96 (0.45)	5.88 (0.76)	7.96 (0.87)	2.50 (0.38)
BLG0024-1-2	36.67 (1.55)	35.13 (1.54)	38.67 (1.59)	11.33 (1.04)
BLG0003-2-1	48.71 (1.65)	39.13 (1.59)	55.42 (1.71)	9.33 (0.94)
BLG0036-1	4.33 (0.63)	9.42 (0.97)	10.00 (1.00)	6.00 (0.76)
Sekhar-1	20.67 (1.28)	30.58 (1.48)	37.88 (1.58)	7.50 (0.87)
BLG0079-1	6.92 (0.84)	12.21 (1.08)	15.25 (1.18)	6.08 (0.78)
Local check	106.92 (2.01)	57.38 (1.76)	107.63 (2.03)	14.83 (1.17)
Grand mean	32.37	31.06	45.61	9.45
F test (Genotype)	**	**	**	**
F test (Genotype × Year)	**	**	**	**
LSD (0.05)	0.04	0.03	0.04	0.07
CV, %	2.90	2.00	2.00	6.40

†means of three replications, value in parenthesis indicates log transformed value **- significant at ≤ 0.01 p level

All the genotypes differed significantly ($P \leq 0.01$) with the insect population recorded during summer season of 2018 and 2019. The lower no of aphid (2.96 per plant), whitefly (5.88 per plant), hairy caterpillar (7.96 per plant) and pod borer (2.50 per plant) was recorded in BLG0069-1 followed by the genotypes BLG0036-1 and BLG0079-1 (Table 4). The higher count of aphid (106.92 per plant), whitefly (57.38 per plant), hairy caterpillar (107.63 per plant) and pod borer (14.83 per plant) was found in local check (Table 4).

Relationship between grain yield and insect population

A linear significant negative correlation between grain yield and aphid population per plant ($r = -0.88$), whitefly per plant ($r = -0.94$), hairy caterpillar per plant ($r = -0.92$) and pod borer per plant ($r = -0.89$) was observed representing the best fit having $R^2=77\%$ for aphid, 87% for whitefly, 85% for hairy caterpillar and 80% for pod borer population per plant (Figure 1). Obviously the yield was decreased with the increase in insect population. The predicted linear regression line was also displayed downward slope i.e. $y = -8.76x + 1463.2$, with $R^2 = 0.77$ for aphid per plant, $y = -19.99x + 1800.7$, with $R^2 = 0.88$ for whitefly per plant, $y = -10.28x + 1648.3$, with $R^2 = 0.85$ for hairy caterpillar per plant and $y = -87.24x + 2003.9$, with $R^2 = 0.80$ for pod borer per plant where 'y' denoted predicted yield (kg/ha) of blackgram genotypes and 'x' stood for insect counts like aphid, whitefly, hairy caterpillar and pod borer per plant respectively (Figure 1).

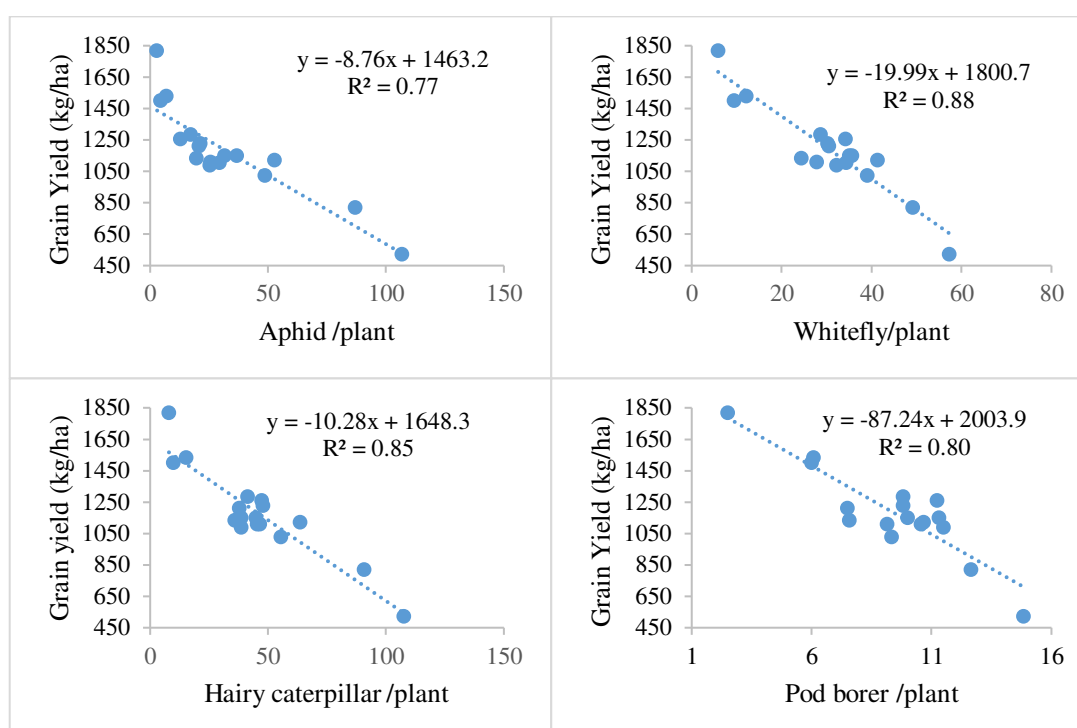


Figure 1. Relationship between grain yield of blackgram genotypes with insect populations per plant at Rampur, Chitwan during summer season of 2018 and 2019.

The development of resistant varieties in pulse crops is an important component of integrated pest management strategies. Although insecticides are effective against sucking pests, defoliator and pod borer complexes, the development of insecticide resistance, short-term crop residues and environmental hazards require alternative eco-safe management methods (Soundararajan *et al.*, 2013). Host plant resistance can play a crucial role in pest control in grain legumes, and resistance to insect pests should be one of the key requirements for the development and release of new crop cultivars to ensure a long cultivar life and cost-effective output (Sharma and Crouch, 2004). From two years field data, three black gram genotypes BLG0069-1, BLG0036-1 and BLG0079-1 had lower number of insect populations, exhibited more resistant in both years and produced higher grain yield (~ 1.5 t/ha) than other genotypes.

Previous efforts on host plant resistance to blackgram insect pests supported the finding of the current experiment (Subedi *et al.*, 2016; GLRP, 2015; Soundararajan *et al.*, 2013). Such findings may be due to biochemical compounds on the leaves that repelled insects from the host plant. Phloem feeding whitefly (*B. tabaci*) induces oxidative stress in black gram plants and the induction of high levels of anti-oxidative compounds, particularly phenols, is likely to play a significant role in black gram defense thus contributing to the bio-protection of these plants against *B. tabaci* infestation (Taggar *et al.*, 2014). Antioxidative compounds have the ability to form insoluble complexes with proteins, act as enzyme inhibitors or are oxidized to toxic quinines, thus rapid accumulation of phenols in resistant genotypes, following whitefly (*B. tabaci*) infestation highlights inducible biochemical pathway of expression of host resistance probably involving synthesis of phenolic precursors and their further oxidation into toxic quinines (Metraux and Raskin, 1993). On the other hand, physical factors such as leaf area, pubescence and lamina thickness must also be taken into account regarding host selection and might play a role in imparting resistance in black gram plants to major insect pests (Taggar and Gill, 2012). The three mechanisms identified as antixenosis, antibiosis and tolerance contribute to the resistance of major insect pests in pulse crops (Dilawari and Dhaliwal, 1993). Several physio-chemical characteristics contribute to insect resistance in pulse (Clement *et al.*, 1994). Presence of dense covering of hairs or trichomes on the leaves/pods confers resistance to many insect species. Allomones such as arcelins, L-canavanine, polyhydroxy alkaloids and saponins have been reported to confer resistance to insect pests in grain legumes (Dilawari and Dhaliwal, 1993).

CONCLUSION

Blackgram genotypes BLG0069-1, BLG0036-1 and BLG0079-1 appear more resistant to major insect pests and produced higher yield than other genotypes. The identified insect resistant blackgram genotypes could be used for national grain legumes research program to develop insect resistant blackgram varieties in the inner terai region of Nepal.

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Authors' contributions

Dr. S. Neupane was the principle investigator of this research while Dr. S. Subedi prepared and finalized the manuscript. Dr. R. Darai helped during field research and Miss T. Sharma helped during data recording and field work.

Conflict of interest

The authors declare that there is no conflict of interest.

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