

Effect of blackgram genotypes and nitrogen on productivity, profitability and resource-use efficiency in maize (*Zea mays*) + blackgram (*Vigna mungo*) intercropping system

SHILPA¹, JANARDAN SINGH² AND NAVNEET KAUR³

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh 176 062

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ABSTRACT

A field experiment was conducted during the rainy season (*kharif*) of 2017 at Palampur, Himachal Pradesh, to study the effect of blackgram [*Vigna mungo* (L.) Hepper] genotypes and nitrogen levels on the performance of maize (*Zea mays* L.) + blackgram intercropping system. The experiment consisting of 12 treatment combinations including 5 genotypes ('Himachal Mash 1', 'DKU 118', 'DKU 82', 'DKU 98' and 'DKU 99'), 2 nitrogen levels (50% and 100% recommended dose of nitrogen) and 2 sole crops (maize and blackgram) was conducted under randomized block design with three replications. Maize + 'Himachal Mash 1' blackgram genotype with 100% recommended dose of nitrogen (RDN) exhibited significantly higher maize equivalent yield (5.04 t/ha), production efficiency (38.7 kg/ha/day), rainfall-use efficiency (2.15 kg/ha-mm), net returns (₹84,444/ha), benefit : cost ratio (3.2) and monetary efficiency (₹650/ha/day). While these attributes were lowest with maize + 'DKU 118' intercropping system with 50% RDN. As sole crops, blackgram recorded significantly higher maize equivalent yield, production efficiency, rainfall-use efficiency, net returns and benefit : cost ratio over maize. Maize + 'Himachal Mash 1' intercropping system with 100% RDN proved to be more productive and profitable treatment under mid-hill conditions of Himachal Pradesh.

Key words : Blackgram, Maize, Nitrogen, Productivity, Profitability, Resource-use efficiency

Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. It is grown on an area of 9.60 million ha with annual production of 26.26 million tonnes, with a productivity of 2,740 kg/ha (USDA, 2017). In Himachal Pradesh, it is grown as sole crop as well as an intercrop with pulses. The area under state is 0.294 million ha with a total production and productivity of 0.737 million tonnes and 251 kg/ha respectively (IIMR, 2016). Blackgram being a short-statured legume crop having short duration and fast-growing nature, can find place in many intercropping systems. It is grown on an area of 3.25 million ha with production of 1.5 million tonnes and yield of 400 kg/ha in the country (FAO, 2016a). It is one of the major pulses in Himachal Pradesh, mostly

grown as an intercrop with maize. It is grown on an area of 0.0079 million ha with production of 0.0036 million tonnes and yield of 449 kg/ha (IIPR, 2016b).

Maize + blackgram intercropping is a viable agronomic means of risk minimizing farmer's profit and subsistence oriented, particularly in the state. The yield advantage of maize in intercropping system with blackgram probably occurred from the difference in timing of utilization of resources by different crops. Intercropping ensures efficient utilization of natural resources like light, nutrients, water and space but also conserve it by reducing soil erosion and lodging, suppresses weed growth thereby helps in yield increment and maintain greater stability in crop yield. Maize + blackgram intercropping system, besides increasing productivity and profitability also improves soil health and conserves soil moisture. Inclusion of blackgram as an intercrop with maize supplies additional nutrient to crop plant by converting and fixing atmospheric nitrogen in available form through symbiosis with rhizobial strains. Intercropping of maize with blackgram increases the amount of absorption photosynthetically active radiation (PAR), light interception, reduces water evaporation and

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¹Corresponding author's e-mail: singhjdr@rediffmail.com

^{1,3}Ph.D. Student, ²Professor (Agronomy), College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh 176 062.

improves conservation of soil moisture.

It is well known fact that maize is a heavy nutrient feeder crop and it responds favourably to fertilization, especially where soils are low in native fertility. It is generally observed that maize fails to produce worthwhile grain yields in plots without fertilizer. Nitrogen is one of the primary nutrients for increasing productivity of maize. Most of the old blackgram varieties are susceptible to higher dose of nitrogen during their growth period, resulting in poor productivity. Since suitable genotypes of blackgram and optimum level of nitrogen for maize + blackgram intercropping system under high rainfall areas were not known, the present investigation was carried out.

The field experiment was conducted during the rainy season (*kharif*) of 2017 at the Research Farm, Department of Agronomy, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experiment was laid out in a randomized block design with 12 treatment combinations including 5 genotypes ('Himachal Mash 1', 'DKU 118', 'DKU 82', 'DKU 98' and 'DKU 99'), 2 nitrogen levels (50% and 100% recommended dose of nitrogen) and 2 sole crops (maize and blackgram) replicated thrice. The soil of the experimental site was silty clay loam with 5.7 pH, 0.56% organic carbon, 132.63 kg/ha available nitrogen, 14.67 kg/ha available phosphorus and 268 kg/ha available potassium. The meteorological data during the crop season revealed that the weekly maximum and minimum temperature ranged from 25.2 to 29.9°C and 11.6 to 20.8°C respectively. The mean relative humidity ranged from 50.6 to 95.3% and total of 2,340.2 mm rainfall were received during the crop season. The mean bright sunshine hours were 112.9 h during the whole of the crop season.

Seeds of maize and blackgram were treated with bavistin @ 2.5 g/kg seed before sowing to protect crop from seed borne diseases. 'Kanchan Hybrid 101' variety of maize and 'Himachal Mash 1', 'DKU 118', 'DKU 82', 'DKU 98' and 'DKU 99' of blackgram were used as test crops/genotypes. Maize and blackgram crops were sown at 60 cm × 20 cm and at 30 cm × 10 cm spacing respectively with a seed rate of 25 and 20 kg/ha, respectively. Blackgram was sown between 2 rows of maize (1:1) as intercrop. Both crops were sown on 14 June 2017.

As per recommended dose of nitrogen, i.e. 120 kg/ha to maize, half dose of nitrogen as per the treatment (100% and 50% of RDN) and recommended dose of phosphorus and potassium, i.e. 60 kg/ha and 40 kg/ha, were applied uniformly as basal application, as urea, single superphosphate and muriate of potash respectively. Fertilizers were not applied to blackgram when it was grown as an intercrop with maize. The remaining 50% of nitrogen was applied at knee-high stage of maize as top-dressing. The experimental field was initially irrigated for preparing seed

bed with sufficient moisture. Stomp (35 EC) was applied at the rate of 4.5 litres/ha within 48 hr of sowing for the control of pre-emergence of weeds and 1 hand-weeding was also done at 45 days after sowing in sole maize and 35 days after sowing in sole blackgram for the control of post-emergence of weeds. One hand-weeding was done in intercropping system after 40 days after sowing. Other package of practices recommended for the region was also followed. Crops were harvested from the net plots (8.8 m²) with the help of serrated sickle and it was sun-dried for 3 days. Maize-equivalent yield (MEY), land-equivalent ratio (LER) and production efficiency were calculated as:

$$\text{MEY} = \frac{\text{Seed yield of blackgram (kg/ha)} \times \text{Price of blackgram seed (₹/kg)}}{\text{Price of maize (₹/kg)}}$$

$$\text{LER} = \frac{\text{Yield of maize as intercrop}}{\text{Yield of maize as sole crop}} + \frac{\text{Yield of blackgram as intercrop}}{\text{Yield of blackgram as sole crop}}$$

$$\text{Production efficiency} = \frac{\text{Maize-equivalent yield (kg/ha)}}{\text{crop duration (days)}}$$

The statistical analysis was done by the standard procedures suggested by Gomez and Gomez (1984). Critical difference (CD) values at $P=0.05$ were used to determine the significant differences between treatment means.

Maize-equivalent yield was significantly affected by different sole and intercropping treatments. The highest maize-equivalent yield was recorded in maize + 'Him Mash 1' at 100% recommended dose of nitrogen (Table 1). Likewise, maize + 'DKU 99' with 100% recommended dose of nitrogen gave at par yields with maize + 'DKU 82' + 100% recommended dose of nitrogen. The lowest maize-equivalent yield was recorded in maize + 'DKU 118' + 50% recommended dose of nitrogen. The 100% recommended dose of nitrogen resulted in significantly higher maize-equivalent yield than 50% recommended dose of nitrogen. The increase in maize equivalent yield was mainly owing to the additional yield advantage of intercropping as well as higher market price of blackgram than that of maize alone. Singh *et al.* (2000), Rana *et al.* (2001) and Sawargaonkar *et al.* (2008) reported that full recommended dose of nitrogen gave significantly higher maize-equivalent yield than half of the recommended dose of nitrogen. Among the sole crops, significantly higher maize-equivalent yield was obtained from sole crop stand of blackgram than maize. Maximum land-equivalent ratio was recorded in maize + 'Himachal Mash-1' + 100% recommended dose of nitrogen while it was minimum with maize + 'DKU 118' followed by maize + 'DKU 82' and maize + 'DKU 98' with 50% recommended dose of nitrogen. Kumar *et al.* (2017) and Takele *et al.* (2017) observed that, intercropping of maize with legumes enhanced maize-equivalent yield and land-equivalent ratio as compared to maize as sole crop.

Production efficiency was also significantly influenced

Table 1. Effect of blackgram genotypes and nitrogen levels on maize-equivalent yield, land-equivalent ratio, production efficiency, rainfall-use efficiency, net returns, benefit : cost ratio, monetary efficiency and monetary advantages index in maize + blackgram intercropping systems

Treatment	Maize-equivalent yield (t/ha)	Land-equivalent ratio	Production efficiency (kg/ha/day)	Rainfall-use efficiency (kg/ha-mm)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio	Monetary efficiency (₹/ha/day)	Monetary advantages index (₹/ha)
Maize (RDN)	3.52	1.00	27.04	1.50	56.6	2.5	435	
Maize + 'Him Mash 1' + 100% RDN	5.04	1.35	38.77	2.15	84.4	3.2	650	26,171
Maize + 'Him Mash 1' + 50% RDN	3.89	1.03	29.90	1.66	60.6	2.6	466	2,489
Maize + 'DKU 118' + 100% RDN	4.47	1.19	34.37	1.91	70.9	2.8	545	14,315
Maize + 'DKU 118' + 50% RDN	3.59	0.96	27.61	1.53	52.9	2.4	407	-3,211
Maize + 'DKU 82' + 100% RDN	4.76	1.27	36.59	2.03	77.6	3.0	597	20,196
Maize + 'DKU 82' + 50% RDN	3.61	0.96	27.77	1.54	53.8	2.4	414	-2,946
Maize + 'DKU 98' + 100% RDN	4.57	1.22	35.17	1.95	73.6	2.9	566	16,510
Maize + 'DKU 98' + 50% RDN	3.61	0.96	27.73	1.54	53.4	2.4	411	-2,945
Maize + 'DKU 99' + 100% RDN	4.83	1.29	37.13	2.06	79.7	3.1	613	21,559
Maize + 'DKU 99' + 50% RDN	3.71	0.99	28.50	1.58	56.1	2.5	432	-1,018
Blackgram (RDN)	4.46	1.00	34.2	1.90	68.9	3.0	530	
SEm $\pm$	0.06		0.4	0.03	1.24	0.03	9.5	
CD ($P=0.05$)	0.19		1.4	0.08	3.68	0.10	28.3	

RDN, Recommended dose of nitrogen.

by different sole and intercropping treatments. The highest production efficiency was recorded in maize + 'Himachal Mash 1' + 100% recommended dose of nitrogen, while the lowest in sole maize crop. Maize + blackgram intercropping with 100% recommended dose of nitrogen resulted in higher production efficiency than 50% recommended dose of nitrogen. Takele *et al.* (2017) also observed positive maize-blackgram interaction. Sole blackgram significantly recorded higher production efficiency than sole maize at recommended dose of nitrogen. Rainfall-use efficiency was also significantly affected by different treatments and followed the similar trend like production efficiency. The rainfall-use efficiency recorded in maize + 'Himachal Mash 1' + 100% recommended dose of nitrogen was 43% higher than sole maize crop (Table 1).

Net returns were significantly influenced by different sole and intercropping treatments (Table 1). Significantly higher net returns were obtained in maize + blackgram genotypes with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Significantly higher net returns were noted in sole blackgram than sole maize crop. Net returns recorded in maize + blackgram intercropping system with 50% recommended dose of nitrogen were significantly lower than sole blackgram but higher than sole maize crop. Like net returns, significantly higher benefit : cost ratio was recorded in maize + blackgram intercropping system with 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Takele *et al.* (2017) also reported that, benefit : cost ratio was enhanced in maize + mungbean + 69 kg N/ha intercropping system.

Monetary efficiency was also significantly influenced by different sole and intercropping treatments. Significantly higher monetary efficiency was obtained from intercropping of maize with blackgram genotype ('Himachal Mash 1') at 100% recommended dose of nitrogen than 50% recommended dose of nitrogen. Sole blackgram resulted in higher monetary efficiency than sole maize. The maximum monetary advantages index was also recorded in maize + 'Him Mash 1' + 100% recommended dose of nitrogen. Intercropping of maize with 'DKU 118' followed by 'DKU 82', 'DKU 98' and 'DKU 99' genotypes with 50% recommended dose of nitrogen resulted in negative monetary advantages index (Table 1).

It is inferred that maize + 'Himachal Mash 1' with 100% recommended dose of nitrogen was better for enhancing productivity and profitability besides increasing resource-use efficiency under mid-hill conditions of Himachal Pradesh.

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