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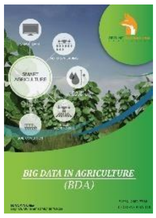

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RESEARCH ARTICLE

EFFECT OF INTERCROPPING SYSTEM OF MAIZE/BLACK GRAM IN SURKHET VALLEY, NEPAL

Krishna Bohara[a]*, Roop Kishore Sharma[b], Gourav Verma[c], Hari Prasad Subedi[d], Dhirendra Man Thapa[e]

[a]Hemvati Nandan Bahuguna Garhwal University (A Central University), Srinagar, Uttarakhand
[b]Department of Agriculture, Hemvati Nandan Bahuguna Garhwal University (A Central University), Srinagar, Uttarakhand
[c]Hemvati Nandan Bahuguna Garhwal University (A Central University), Srinagar, Uttarakhand
[d]Bright Madhyapashim Agriculture and Forestry Campus, AFU, Surkhet, Nepal
[e]Graduate School of Agriculture and Forestry Science, Mid-West University, Surkhet, Nepal
**Corresponding Author Email: krishnabohara1112@gmail.com*

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ABSTRACT

Maize (Zea mays L.), the queen of cereals, is planted with wide spacing and so it offers the scope of intercropping. Considering the benefits of cereal-legume association, an experiment on Maize/ Black Gram intercropping system was conducted during the summer season of 2022 at Shree Nepal Rashtriya Chandraganga Secondary School, Karnali province, Surkhet District. The experiment was laid out in Randomized Block Design split into three blocks, each with seven plots and treatments were comprised of seven cropping systems, namely, T_1: Maize/ black gram in additive series, T_2: Maize/ black gram in replacement series, T_3: Maize + Black Gram (1:2), T_4: Maize + Black gram (1:1), T_5: Maize + Black Gram (2:2), T_6: Sole maize (Zea mays) and T_7: Sole black gram (Vigna mungo L.). Line sowing of Arun-2 maize was done with a spacing of 60 cm × 25 cm in sole maize. A Khajura Mash-1 variety of black gram was sown with 25 cm × 10 cm spacing. As per the treatments, single and double rows of intercrops were taken in between maize. The result indicated that intercropped legumes improved the yield components of maize and offered some bonus yield. The maximum maize grain yield (2258 $kgha^{-1}$) was noted with sole maize and sole black gram (793$kgha^{-1}$). It was followed by Maize/Black gram with 1:2 ratios (2031 $kgha^{-1}$) and (703 $kgha^{-1}$) respectively. The intercropping combination of maize + black gram (1:2) recorded the highest net return having benefit-cost ratio of 1.76. Similarly, the lowest maize grain yield (1718 kg ha^{-1}) and (476$kgha^{-1}$) was noted with Maize + Black gram in the replacement series. But the lowest benefit cost was recorded at 1.37 in Maize/ Black gram (2:2). Intercropping had a significant effect on all treatments and was best performed in maize and black gram (1:2) treatment at Surkhet condition.

KEYWORDS

Intercropping, Production efficiency, Sustainable Yield, Land Equivalent, Benefit-cost

1. INTRODUCTION

Maize is a cereal grain that was first domesticated by indigenous peoples in southern Mexico. It is one of the most adaptable emerging crops, able to thrive in a variety of agro-climatic conditions. Due to its superior genetic yield potential compared to other cereals, maize is referred to as the "queen of cereals" in many countries (Singh, 2002). Maize serves as a basic raw material as an ingredient in thousands of industrial products, including starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package, and paper industries. This is in addition to serving as a staple food for humans and high-quality animal feed. Maize is produced more extensively than other cereal crops worldwide. On a global scale, the total area planted with maize was 190.63 million hectares, and its production totaled 1076.23 million tons with an average productivity of 5.65 tons per hectare (USDA, 2018). The majority of Nepalese living in hills eat primarily maize, which is the second-most important food grain crop in the country (Upadhyay *et. al.,* 2007). The total arable land in Nepal is 9,00,288 hectares, with 2,300,121 metric tons of maize produced, yielding 2,555 kg per hectare, and contributing about 24.93% of the total production of edible grains (MOAD, 2017). The yield of maize is 2.56 Mt/ha on average, which is quite low when compared to other developed nations. In the months of kharif and spring/summer, black gram is grown as a single crop, a mixed crop, a catch crop, or a succession of crops under semi-irrigated or rain-fed conditions. Black gram is a highly nutritive grain that can be grown successfully from sea level up to an elevation of 1800 meters. It contains a high proportion of digestible protein as well as many essential amino acids, minerals, and vitamins. Long-term mono cropping in Nepal has prevented plants from effectively utilizing nutrients. Low crop production and a higher risk of crop failure are both effects of mono cropping systems. Since maize is a crop that requires a lot of space, planting legumes in the spaces between the rows could be profitable. Major issues with cereal-based sole cropping systems in Nepal include low nitrogen inputs, low crop yields, and low land productivity. These issues might be resolved by increasing crop diversity and intensification by using legumes as intercrops. The maize-legume intercropping system improves soil health, retains soil moisture, and increases overall output in addition to increasing productivity and profitability (Padhi & Panigrahi 2006, Ummed *et. al.,* 2008). Based on the cropping system in agriculture, this study can produce a variety of knowledge and ideas. It is beneficial to understand the yield differences and the impact of intercropping on the soil. It's crucial for maintaining farm output to restore biodiversity by cultivating a variety of crops and utilizing farming techniques that effectively utilize the resources at hand (Scherr & McNeely, 2008). So, to maintain soil fertility management and crop production, the present study was carried out to investigate the ideal intercropping combination at Surkhet conditions.

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2. Materials and Methods

2.1 Experimental Sites

In 2022, the experimental site was located at "Shree Nepal Rashtriya Chandraganga Secondary School" Karnali Province at Surkhet district, under the direction and supervision of Mr. Hari Prasad Subedi, Assistant Professor of Entomology. The purpose of the experiment was to investigate the intercropping system of maize and black gram in the Surkhet environment. The location of the site is approximately 596.3 kilometers west of Kathmandu, the nation's capital. This location is approximately 21700 meters above sea level and has an annual rainfall of 1609 millimeters, with latitude of 28°N and a longitude of 81°E and has a moderate climate, with winter lows of 5 °C and summer highs of 38 °C.

2.2 Physio-Chemical Properties of Soil

Before the start of the experiment, twenty randomly selected soil samples were taken from the experimental blocks at depths ranging from 0 to 30 cm. As a result of long-term land use and soil management practices, the top 30 cm of soil was chosen because it is the depth where the majority of changes are anticipated to occur. Four composite soil samples were prepared and analyzed at the Central Soil and Manure Analysis Laboratory Banke in Khajura, Nepal. Total nitrogen was determined by the Kjeldahl Distillation Unit (Bremner, 1965), available phosphorous by the Modified Olsen Bicarbonate Method (Watanabe & Olsen, 1965), and available potassium by the Ammonium Acetate Extraction Method (Pratt, 1965). Organic matter was determined by the Wet Digestion Method (Walkley & Black, 1934), pH by the Beckman Glass Electrode pH meter, and soil texture by the hydrometer method.

Table 1: Soil Properties of Experimental Sites

S.N.	Properties	Results
1	Physical properties	
a.	Sand (%)	58.10%
b.	Silt (%)	15.40%
c.	Clay (%)	26.10%
	Textural class (USDA textural triangle)	Sandy Loam
3	Chemical properties	
a.	Soil pH	6.51
b.	Soil organic matter (%)	0.29%
c.	Total nitrogen (%)	0.10%
d.	Available phosphorus (kg ha^{-1})	78.6
e.	Available potassium (kg ha^{-1})	59.59

2.3 Details of the Experiment

The spacing between blocks and plots was set at 1 m and 1 m, respectively, to facilitate various intercultural operations. The total area covered was 36 m x 15 m, with each plot measuring 4 m x 4 m and a total of 21 plots. The spacing for sole maize row to row and plant to plant was 60cm * 25cm and 30cm * 10cm for sole black gram row to row and plant to plant, respectively.

2.4 Treatment Details

The experiment field was designed in Randomized Block Design (RBD) with seven treatments, and three replications of each treatment. The entire experimental plot was split into three blocks, each with seven plots. Arun-2 variety of maize and Khajura Mash-1 variety of black gram were procured from Nepal Agricultural Research Council (NARC) Dashrathpur, Surkhet.

Table 2: Treatment Details

Symbol	Treatments
T_1	Maize+ Black gram in additive series
T_2	Maize+ Black gram in replacement series
T_3	Maize/Black gram (1:2)
T_4	Maize/Black gram (1:1)
T_5	Maize/ Black gram (2:2)
T_6	Sole maize
T_7	Sole Black gram

2.5 Fertilizer Application

The plots received the required fertilizer concentrations of urea, di-ammonium phosphate, and murate of potash, which were 60, 40, and 40 kg NPK ha-1, respectively. Half of the nitrogen, as well as the full doses of phosphate and potash, were applied as basal doses in each plot for the solo maize and maize + black gram treatments. However, all fertilizers were applied as basal for the single black gram treatment. The other half of the nitrogen was applied as a top dressing to maize and maize + legume plots at the knee-height stage.

2.6 Seed Sowing

After five days of land preparation, seeding by drawing lines was carried out. Each experimental plot had sowing on April 17, 2022, at a depth of 4-5 cm. The seeds were sowed under various treatments.

- **Maize/ black gram in additive series**

Maize was sown at a plant-to-plant distance of 25 cm and a row-to-row distance of 60 cm. Similarly to that, 208 seeds, approximately 20% of the black gram, were dispersed.

- **Maize/ black gram in replacement series**

There were 90 maize seeds sown. 50% of the maize population was uprooted on the eleventh day of seeding, and 50%, approximately 260 seeds, of black gram were broadcasted.

- **Maize+ Black Gram (1:2)**

In line sowing, a row of maize was planted with a plant-to-plant distance of 25 cm, and two rows of black gram were sown with a plant-to-plant distance of 30 cm and 10 cm, respectively. Maize was once more sowed in a row at a distance of 30 cm.

- **Maize +Black gram (1:1)**

In this treatment, maize was sown by making a 25cm plant-to-plant distance. And leaving 30 cm distance black grams were sown at a 10 cm distance and vice versa.

- **Maize + Black Gram (2:2)**

In this treatment at first 2 rows of maize were sown at a 60 cm distance and leaving a 30 cm distance 2 rows of black gram were sown and vice versa.

- **Sole maize**

In this treatment, Sole maize was sown at the plant to plant distance of 25 cm and row to row distance of 60 cm.

- **Sole black gram**

In this treatment, sole black grams were sown at the plant to plant distance of 10 cm and a row of row 30 cm.

2.7 Economics Parameters

2.7.1 Sustainable Yield Index (SIY)

The sustainable yield index (SYI) is a product of actual yields over a long period, and a high SYI indicates better management practices that can generate good yields over time. A sustainability yield index is a number between 0 and 1. The sustainable yield index was calculated by,

SYI= Y-SD/ Ymax

Where,

SYI = Sustainability Yield Index

Y = Average yield over years (n= 0, 1, 2, 3, 4…)

SD = Standard Deviation

Ymax = Maximum yield obtained in any of the years.

2.7.2 Land Equivalent Ratio (LER)

The most commonly used index in intercropping to measure land productivity is the land equivalent ratio (LER). The LER is a standardized index that measures the amount of land required by sole crops to produce the same yield as intercrops. The LER was calculated using the following formula,

$$LER = \frac{YBG \text{ in a mixed stand}}{YBG \text{ in pure stand}} + \frac{YMZ \text{ in a mixed stand}}{YMZ \text{ in pure stand}}$$

Where,

LER = Land equivalent ratio

YCB = Yield of Black gram

YMZ = Yield of maize crop

2.7.3 Benefit-Cost Ratio (BCR)

The Benefit Cost (BCR), which can be expressed in monetary or qualitative terms, is a relationship between relative costs and benefits. To calculate the gross return, revenue from product sales was obtained. Consequently, benefit-cost ratio was calculated using the following formula,

B: C ratio = Gross return/ Total cost

3. Results and Discussion

3.1 Maize

In 45 and 60 DAS, the Maize/Black gram reached a maximum height of 82.6 cm and 193.5 cm respectively. In 60 DAS, the Maize+ Black gram in the replacement series had the shortest plant height of 181.4cm.

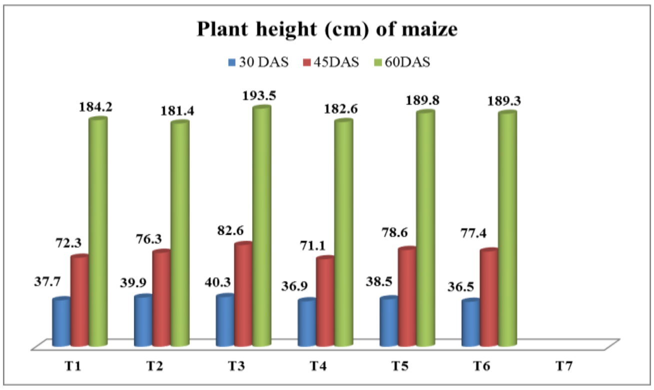

Figure 1: Effect of different treatments on plant height of maize at different growing stages

3.1.1 Yield Parameters of Maize

Cobs per plant were recorded as being at their highest in Sole maize, which had a total of 1.33, followed by Maize/Black gram (1:2) 1.29 and lowest in Maize + Black gram in replacement series (1.01). Similar findings were confirmed in 2019 by Parimaladevi *et. al.,* and concluded due to an increase in nitrogen content. Likewise, Sole Maize recorded the highest number of grains per row (15.5). Mandal *et. al.,* (2014) noticed similar results during the study of the Growth and yield of summer maize as influenced by intercropping systems in West Bengal. In Maize/Black gram (1:1) plot the minimum number of grains per row was 14.8. The highest numbers of grains per cob were found in sole maize (403) and Maize/ Black gram (2:2) plots (401) respectively. This might be because there was no inter-specific competition, which led to higher photosynthetic efficiency, better light interception, higher dry matter accumulation, and the translocation of manufactured food from the source to sink (Sheoran et. al., 2010).

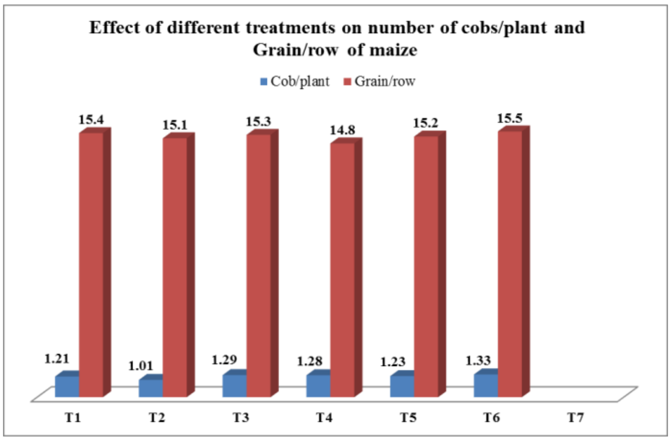

Figure 2: Effect of different treatments on number of cobs per plant and Grain per row of maize

Table 3: Effect of different treatments on Grain per cob, 1000 grain weight and Grain yield of maize

Treatment	Treatment Details	Grain/cob	1000 grain wt. (gm)	Grain yield (kg/ha)
T_1	Maize+ Black gram in additive series	386	138.1	1936
T_2	Maize+ Black gram in replacement series	383	135.6	1718
T_3	Maize/Black gram(1:2)	399	138.8	2031
T_4	Maize/Black gram(1:1)	395	136.9	1994
T_5	Maize/ Black gram(2:2)	401	139.3	1738
T_6	Sole maize	403	141.7	2258
T_7	Sole Black gram			
	Grand Mean	394.5	**138.4**	**1945.83**
	SEM (±)	3.07	**0.78**	**74.95**
	LSD0.05	3.27**	**2.89*** **	**32.51*** **

Treatments means followed by the common letter (s) within a column are non-significantly different from each other based on DMRT at a 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

3.2 Black Gram

Effect of different treatments on yield attributing characters of Black Gram

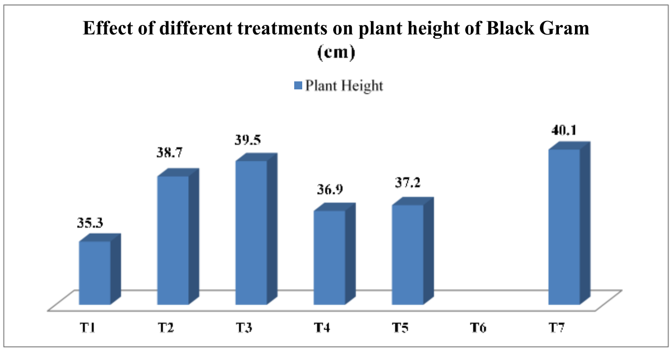

Figure 3: Effect of different treatments on plant height of Black Gram (cm)

The maximum plant height on black gram was 40.1 cm in Sole Black gram, and the minimum plant height was recorded in Maize + Black gram in additive series (35.3 cm). Sheoran *et. al.,* in 2010 found that the monoculture of black gram was superior in height due to less competition and adequate nutrient supply.

The maximum number of pods per plant was marked in treatment Sole Black gram (22.7) and followed by Maize/Black gram (1:2) and Maize/ Black gram (2:2) respectively. It was might be due to proper spacing and adequate utilization of supplied nutrients with minimum weed interference (Sardana *et. al.,* 2017) at sole black gram. Similarly, the maximum number of seeds per pod recorded on Maize/Black gram (1:2) was 6.3. Likewise, 1000 seeds were weighed up to 38.9 gm in Sole Black gram. Black gram monoculture produced higher yields than intercropped culture. According to Singh *et. al.,* (2009) and an earlier finding by Sheoran *et. al.,* (2010) reduced weight may be a result of maize plants shading out other plants and increasing competition. The treatment of Sole Black gram had the highest (793 kg/ha) output per hectare, and followed by 703 kg/ha in Maize/Black gram (1:2) treatments. Black gram monoculture suggests greater yields than in other treatments. The magnitude of yield reduction from intercropping with maize varied depending on plant population and spatial arrangement of the component crop. The lowest yield (476 kg/ha) was found for maize + black gram in the replacement series.

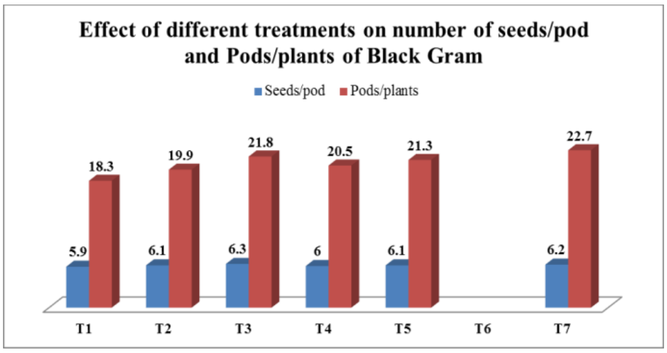

Figure 4: Effect of different treatments on number of seeds/pod and Pods/plants of Black Gram

Table 4: Effect of Different Treatments on Yield Attribute Characters of Black Gram			
Treatment	**Treatment Details**	**1000 grain wt. (gm)**	**Seed yield (kg/ha)**
T_1	Maize+ Black gram in additive series	35.2	573
T_2	Maize+ Black gram in replacement series	36.5	476
T_3	Maize/Black gram (1:2)	37.7	703
T_4	Maize/Black gram (1:1)	34.5	638
T_5	Maize/ Black gram (2:2)	36.8	691
T_6	Sole maize		
T_7	Sole Black gram	38.9	793
	Grand Mean	36.6	645.67
	SEM (±)	0.65	45.16
	LSD0.05	2.46***	**41.73****

Treatments means followed by the common letter (s) within a column are non-significantly different from each other based on DMRT at a 5% level of significance. DAT = Days after transplanting, LSD = Least significant difference, SEM = Standard error of mean and CV = Coefficient of variation.

3.3 Economic Analysis

The maximum value of the sustainable yield index was 0.83 in two treatments namely, Maize/Black gram(1:2) and Maize/Black gram(1:1) respectively while the minimum (0.73) at Maize + Black gram in additive series. Similarly, the highest land equivalent ratio (1.73) was obtained from Maize/Black gram (1:2). Intercropping maize with black gram yielded land equivalent ratio values greater than one when compared to sole crops, indicating higher total productivity of the system and yield advantage due to intercropping. The benefit-cost ratio of maize/black gram (1:2) produced the best results (1.76). However, the benefit-cost ratios for solely grown maize and solely grown black gram were 1.03 and 1.17 respectively. In maize-based intercropping systems, Marer *et. al.,* (2007) obtained higher net returns and the findings agreed with those of Parimaladevi *et. al.,* (2019).

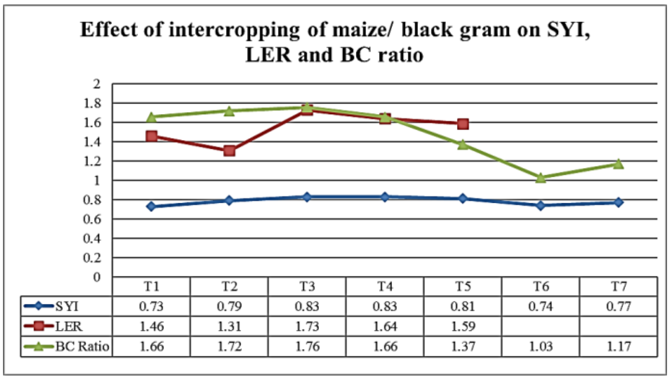

Figure 5: Effect of intercropping in maize/ black gram on SYI, LER and BC ratio

4. Conclusion

The Maize/Black Gram had the highest gross profit among the treatments. In the monoculture of maize and black gram, intercropping was always beneficial, with a higher benefit-cost ratio. In terms of vegetative and yield parameters, sole crops were superior in the majority of cases. Intercropping had a significant effect on all treatments. We can conclude from the experiment that intercropping maize and black gram in a ratio of 1:2 were best at Surkhet condition.

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