Journal of Plant Biota

Original Research Article
ISSN: 3048-4863
Journal homepage: https://plant.researchfloor.org/

Intercrop Production of Sesame with Green Gram Optimized for Humera, Ethiopia

Dawit Fisseha Weldearegay*

Ethiopian Agricultural Research Institute,Tigray Agricultural Research Institute, Humera Agricultural Research Center, Crop Department,Humera, Tigray, Ethiopia

Abstract

Sesame monocropping dominates crop management in the research area, leading to low yield, high insect frequency, and poor soil fertility. The purpose of this study is to assess how intercropping green grams and sesame affects land productivity.To assess the productivity of intercropping sesame varieties with green gram at varying row spacing in one environment of Humera, Western Tigray, Ethiopia, three factorial experiments were carried out in three replicates: (i) cropping system at two levels (mono cropping and intercropping); (ii) two sesame varieties (setit1 and local); and (iii) row spacing at three levels (40 cm, 60 cm, and 80 cm). The findings demonstrated that varied numbers of row spacing and intercropping methods had a significant impact on different yield components of green grams and sesame. Monocultures planted at 40 cm row spacing had the maximum grain yields of both sesame and green gram (6.9 q/ha, 5.3 q/ha, and 13.2 q/ha for setit1, local, and green gram, respectively). Conversely, with intercropping setit1, local, and green gram at 80 cm row spacing, the lowest yields (2.7 q/ha, 2 q/ha, and 3.1 q/ha) were achieved.Interceppinggreen gram grown at all row spacing gained a significantly lower number of pods dropped over mono-cropping green gram at all row spacing.The highest LER values was gained in intercropped setit1 and local sesame at 60 cm spacing (2.6 and 2.2) while the least (1.1 and 1.2) in 40 cm spacing respectively.Oil content of the tested treatments was similar to the mono-cropping system.

Keywords: *grain yield, green gram, Land equivalent ratio, row spacing, mono-cropping.*

ACKNOWLEDGEMENTS

I am appreciative of the Tigray Agricultural Research Institute's financial assistance in doing this study. For their assistance with the field experiment, I also like to thank the members of the Crop Case Team at the Humera Agricultural Research Center.

ACRONOMY

ATA	Agricultural Transformation Agency
CIMMYT	International Center for Wheat and Maize Improvement
CSA	Central Statistics Agency
ECE	Ethiopian Commodity Exchange
ENUPI	Ethiopian National Urban Planning Institute
FAO	Food and Agricultural Organization
HuARC	Humera Agricultural Research Center
LER	Land Equivalent Ratio
MOARD	Ministry of agriculture and rural development
MOT	Ministry of Trade
SBN	Sesame Business Network
UNATAD	United Nations Conference on Trade and Development
TARI	Tigray Agricultural Research Institute
USDP	United States Development Program

1. INTRODUCTION

Global sesame (Sesamumindicum) grain production is about 3,000,000 Mg yr^{-1} with about 1,200,000 Mg yr^{-1} traded with a value of $1 billion [1]. [2] Sesame is the main oil seed crop in Ethiopia with about 270,000 ha yr^{-1} planted and 172,000 Mg yr^{-1} harvested.

There is a huge demand for sesame. Monocropping accounts for the majority of production. Low soil fertility and pest abundance have become major issues in the research area as a result of the repeated production of sesame on the same plot of land [3]. Its production has decreased and is no longer sufficient to meet the conventional income of the producers [4]. Yields are poor, though. The crop requires a lot of sunlight. Row spacing is a point of contention; the Tigray Agricultural Research Institute Humera Agricultural Research Center recommends 40 x 10 cm spacing, whereas the Ethiopian Agricultural Transformation Agency (ATA) suggests 80 x 10 cm.

Green gram (Vigna radiate L. Wilczek) is a relatively minor pulse crop in Ethiopia but adapted to high temperatures with good market demand and adapted to intercropping [5]. Crop residues of green gram are valued for fodder. The crop is susceptible to wind damage during pod-fill due to lost pods [6]. Intercropping sesame with green gram has promise. The taller sesame plants intercept much sunlight while protecting green gram from wind damage.Since the interspecific facilitation systems clearly encouraged soil N supply and water complementary use, they were advantageous for increasing grain output and soil labile carbon input [7]. However, information for optimized management of the intercropping system is inadequate.

The production of sesame is dominated by monocropping, and due to the repeated production of the crop on the same plot of land, low soil fertility and pest abundance have become major issues in the research area [3]. The crop's production has decreased and is no longer sufficient to meet the conventional income of the producers [4], although yields are poor. The crop requires a lot of sunlight, and row spacing is a point of contention; the Ethiopian Agricultural Transformation Agency (ATA) suggests 80 x 10 cm spacing, while the Tigray Agricultural Research Institute Humera Agricultural Research Center

05 September 2024: Received | 15 October 2024: Revised | 17 November 2024: Accepted |02 December 2024: Available Online

Citation: Dawit Fisseha Weldearegay (2024). Intercrop Production of Sesame with Green Gram Optimized for Humera, Ethiopia. *Journal of Plant Biota.* **34 to 40. DOI: https://doi.org/10.51470/JPB.2024.3.2.34**

Dawit Fisseha Weldearegay | dawitweldeareagy@gmail.com

recommends 40 x 10 cm spacing.

2. MATERIALS AND METHODS

At the Humera Agricultural Research Center (HuARC), located at 610 meters above sea level and at 14°15' N and 36°37' E, a field experiment was conducted in 2017. The climate in Humera is hot and semi-arid, with an average annual rainfall of 443.5 mm, 90% of which falls between June and September. With a mean summer temperature of 28.2°C, evapotranspiration is high [8]. With less than 2% organic matter, deep Vertisol clay is the most common form of soil.

As most farmers did on their fields, sesame was grown at the experiment location for four years in a row. Prior to sowing, the area was harrowed and plowed using a moldboard attached to a tractor.Nationally released sesame variety known as setit1, local sesame variety, and released mung bean variety known as Arkebe were used in thistrial.Three factorial experimentsset with three replicates were appliedto compare monoculture cropping with intercropping, sesame cv. Setit1 with a popular local cultivar, and row spacing of 40-, 60- and 80-cm. Days to maturity were 85-95, 90-105, and 63-70, respectively, for the Setit1 cultivar, the local sesame cultivar, and the green gram cultivar named. Plant height was >1.25 m for sesame and < 0.5 m for green gram. Plots were 4.8 by 2.5 m, with 1.5 m separating blocks and 1 m separating plots.

Within row plant spacing was 10 cm for both crops and green gram row spacing was 40 cm with an additive intercrop planting pattern with green gram planted between rows of sesame. Planting was on 21 July for sesame and 4 August for green gram.

Plant height, branch plant^{-1}, green gram pod plant^{-1}, sesame capsule plant^{-1}, and 1000-kernel weight were determined for five randomly selected plants plot^{-1}. The number of dropped pods was counted and divided by the estimated pod plot^{-1} to determine the percent dropped. Seed yields were determined from the harvest of the whole plot area. The oil content of sesame seed was determined from 40 g samples with Nuclear Magnetic Resolution at Holetta Agricultural Research Center in Ethiopia.

Intercrop land productivity efficiency was measured as the land equivalent ratio (LER) [9] where LER = (sesame intercropped yield/sesame sole crop yield) + (green gram intercropped yield / green gram sole crop yield). Genstat 14 (Numerical Algorithms Group, Oxford, England) was used to do the analysis of variance and the Duncan multiple range test for means separation with a least significant difference of 5% [10].

3. RESULTS AND DISCUSSION

3.1 Yield and yield component

3.1.1 Sesame length of capsule bearing zone

The maximum height at which the capsules can be held—also referred to as the sesame length of the capsule carrying zone—is one of the last elements that affects sesame production. Due to the combined effects of variety, cropping strategy, and row spacing, the analysis of variance showed a significant variation in the mean length of the capsule bearing zone (Table 1). Intercropping local and setit1 types at 40 cm row spacing had the lowest length scores among the interactions (47 cm and 42 cm, respectively), in contrast to intercropping at 60 cm (71 cm) and 80 cm (76 cm) row spacing. However, Table 1 shows no discernible difference between intercropping local at 60 and 80 cm spacing. There was no discernible difference in length between the monoculture system grown locally at 40 cm, 60 cm, and 80 cm row spacing, and 69 cm, 72 cm, and 75 cm, respectively.

Maximum length of capsule bearing zone (83 cm)was recorded in mono cropping setit1 variety at 80 cm, mono setit1 at 60 cm (82 cm), intercropped setit1 at 80 cm (80 cm), intercropped setit1 at 60 cm (79 cm), mono local at 80 cm (75 cm) and intercropped local at 80 cm (76 cm) which showed insignificant difference between them (Table 1).

[11]Foundsignificant results on the length of capsule bearing zone intercropped with soybean and monoculture sesame cropping.

3.1.2 Sesame number of capsules per plant

This is a crucial factor that limits the final yield of sesame. The current study found that the interaction effect of variety, cropping system, and row spacing was statistically significant ($p<0.05$) on the number of capsules per plant, as shown in Table 1. The intercropped local (44) and setit1 (45) at 40 cm row spacing produced the fewest capsules per plant, while the treatments of the intercropping system and row spacing affected the number of capsules produced per plant. The setit1 at 60 cm and 80 cm row spacing produced a significantly higher number of capsules per plant than the other interactions. Monoculture setit1 scored a maximum number of capsules at 80 cm spacing (83) and 60 cm spacing (82) closely followed by intercropped setit1 at 80 cm (80) and 60 cm (79) row spacing.

Setit1 produced significantly more capsules than local when cultivated in intercropping at 60 and 80 cm spacing because of its genetic vigor. This may be due to the competitive function between and among species in the short spacing rows with respect to light, energy, and space. These findings are in line with those of [12], who discovered that plants in wide rows were less likely to face intra-specific competition and tended to be more vigorous and prolific. Similarly, [13],[14], [15], and [16] reported that all the sole sesame treatments viz., T1 – sole sesame, T2 – sole sesame (Paired rows at 30-60 cm), and T3 – sole sesame (Paired rows at 30-30-75 cm) were statistically at par and recorded more number of capsules per plant as compared to intercropping treatments. [17]Also discovered highest number of capsules per plant (69.20) when sesame was cultivated along and with inoculated green gram in 3:3 row arrangements than 1:1 and 2:2 ratios.

Table 1: *Interaction effects of variety, cropping system, and row spacing on meanlength of capsule bearing zone, number of capsules plant^{-1}, yield and yield components of sesameat Humera, Western Tigray in 2017*

Cultivar	Local cultivar			Setit1		
Row spacing	40 cm	60 cm	80 cm	40 cm	60 cm	80 cm
Capsule bearing stem length, cm						
Intercrop	47^{e}	71^{cd}	76^{abcd}	42^{c}	79^{a}	80^{a}
Monoculture	69^{d}	72^{bcd}	75^{abcd}	45^{bc}	79^{a}	80^{a}
Number of Capsule plant-1						
Intercrop	44^{f}	73^{cd}	72^{cd}	45^{f}	79^{ab}	80^{ab}
Monoculture	63^{e}	72^{d}	73^{cd}	77^{bc}	82^{a}	83^{a}
LER						
Intercrop	1.2^{c}	2.2^{b}	2^{b}	1.1^{c}	2.6^{a}	2.1^{b}
Monoculture	1^{d}	1^{d}	1^{d}	1^{d}	1^{d}	1^{d}
1000 seed weight (gm)						
Intercrop	2.8^{ab}	2.96^{ab}	3.1^{ab}	2.73^{b}	3.1^{ab}	3.23^{ab}
Monoculture	2.86^{ab}	3.1^{ab}	3.2^{ab}	3.17^{ab}	3.37^{ab}	3.43^{a}
Yield (q/ha)						
Intercrop	4.3^{d}	3.2^{e}	2^{f}	5^{c}	5.9^{bc}	2.7^{e}
Monoculture	5.3^{bc}	3.2^{e}	1.9^{f}	6.7^{a}	4^{d}	2.7^{e}

3.1.3 Green gram number of pods per plant

Similar to other factors, the number of pods produced by a plant is a crucial factor in determining the ultimate yield. The difference in green gram pods per plant between intercropping, row spacing, and interactions was significant enough. There were notable variations in the quantity of pods per plant when the cropping strategy and row spacing were combined (Table 2). Treatments had no effect on pod plant-1, with the exception of intercropping and 40-cm row spacing resulted in 21% less pod plants than the mean for the other treatments. Treatments with 60- and 80-cm sesame row spacing had no effect on seed pod-1, while 40-row spacing resulted in 21% fewer. Dropped pods were most and least common in solitary crops with 40- and 80-cm row spacing, respectively, and more than ten times as common in sole crops as in intercrops.

There was no significant difference in the quantity of pods per plant between the row spacing and monoculture green gram treatments. Thus, monoculture green gram planted at 40 cm, 80 cm, and 60 cm row spacing produced 36, 35, and 34 pods per plant.

The mung bean intercropping with setit1 and local at 40 cm row spacing produced the fewest pods per plant, which may have been caused by the narrow row spacing, the shading effect of the tall, branched sesame on green gram light absorption, and the increased competition for growth resources from the related sesame varieties as its density increased. In light of this, the results indicated that green gram intercropping between broader sesame rows was less impacted by sesame.

In line with the current findings, [18] and [19] observed significant changes in the quantity of pods per plant of green gram under various intercropping strategies and row spacing. Additionally, it has been found by [20], [21], [22], and [18] that intercropping on different yield components of green gram grown in conjunction with sesame under varying row spacing significantly influenced the number of pods at narrow row spacing. Accordingly, [23] found that reduced grain yields in intercrops compared to monoculture crops were caused by a decrease in the number of grains per unit area in sorghum + green gram and sorghum + pigeon pea intercropping.

3.1.4 Green gram number of pod dropped

Major issues in green gram production include flower drop, pod drop, and wind-induced pod cracking, all of which have significantly reduced yield [6]. Twelve, eight, and six rows of green grams were planted in the plots (4.8 m wide by 2.5 m long), which were used for both intercropping and monoculture cropping in this study. The row spacing was 40 cm, 60 cm, and 80 cm, respectively. To see the effects of intercropping and row spacing, the number of pods dropped per plot was counted from pod setting onward.

Cropping systems, row spacing, and their interactions had a substantial impact on the quantity of pods dropped per plot, according to analysis of variance. The quantity of pods dropped per plot was significantly impacted by the interaction between the cropping system and row spacing (Table 2). Compared to intercropped green gram sown at all row spacing, monoculture green gram grown at 40, 60, and 80 cm row spacing had noticeably larger pod drops. Planting monoculture green grams at 40, 60, and 80 cm intervals resulted in scores of 3500, 2374, and 1890 pods fell per plot, or 32%, 33%, and 35% of the total number of pods that would be on the plot, respectively. Conversely, compared to solitary green gram at all row spacing, intercropped green gram produced at all row spacing gained a much lower number of pods dropped. However, in all row spacings, no discernible effects were found between intercropped green grams.

Compared to solitary green gramme, which is directly exposed to wind, the intercropped green gramme was shielded from wind by taller sesame varieties, which may explain the difference in the amount of pods dropped per plot between the two types. To put it another way, the intercropped green gram may be protected from the wind by the higher sesame crops. In terms of row spacing, green grams with narrower separation have a higher plant density than those with broader spacing; that is, plants separated 40 cm apart had more plants than plants set 60 and 80 cm apart. As a result, more pod drops from more plants per plot would be seen in windy conditions than from fewer plants per plot.The current study's findings concur with those of [24], who found that when green gram was grown alone as opposed to when it was interplanted with sorghum, the greatest amount of pods were lost per plot.

3.1.5 Green gram number of seed per pod

Analysis of variance for the intercropping system, interaction treatments, and row spacing showed a significant variation in the quantity of seeds per pod, as seen in Table 2. Compared to all other intercropped interactions, including the interaction between intercropping and row spacing, intercropped green gram grown at 40 cm row spacing yielded significantly fewer seeds per pod (7). Although the difference was slight, intercropping green grams with 60–80 cm row spacing resulted in more seeds per pod.

The number of seeds per pod was not significantly impacted by the monoculture farming system or the row spacing interactions. The number of seeds per pod for mono green grams planted at 80 cm, 60 cm, and 40 cm row spacing was statistically comparable (11.9, 12, and 10.9). Both kinds of sole and intercropped green gram produced at 60 cm and 80 cm row spacing had comparable effects on the quantity of seeds per pod when compared at the three spacings. However, compared to intercropped green gram at 40 cm spacing, sole green gram seeded at 40 cm spacing yielded much more seeds per pod.

Interspecies competition for growth factors, particularly light, was a major contributor in the steady decline in the quantity of seeds at closer spacing. [25], [19], and [24].[26] The results concurred with the current outcome as well.

3.1.6 Sesame thousand seed weight

One measure of sesame quality is the weight of a thousand seeds. As a rule, sesame seeds must weigh more than 3 grams per thousand, have 40–50% oil, be pearly white in color, and be 99% pure in order to be exported [27]. Accordingly, for thousand seed weights of both sesame kinds, the interaction of variety, cropping systems, and row spacing shows a non-significant difference ($p>0.05$) according to the experiment's analysis of variance.

Sole setit1 and local sesame recorded (3.3 gm) and (3 gm) while intercropped setit1 and local gained (3 gm) and (2.9 gm) 1000 seed weight respectively (Table 1). Insignificant values of test weights under intercropping and sole cropping treatments might be attributed to the complementarity of the two crops for intercropping. The reason that intercropped and sole setit1 gained heavier 1000 seed weight might be due to the character that it owned heavier seed weight relative to local sesame.

Similar findings have been demonstrated by [28], who discovered that when sesame and cowpea were interplanted instead of grown alone, a non-significant 1000-seed weight was obtained. The results of the current study were corroborated by [14], [24], and [29], which showed that treatments including larger row spacing had a comparatively favorable impact on 1000 seed weight. [28]Comparing intercropping sesame with other legumes to sole sesame, a similar 1000 seed weight was also noted.

3.1.7 Green gram hundred seed weight

As presented in (Table 2), the cropping system, row spacing and their interaction showed significantly different influences on 100 seed weight of mung bean. In regard to the intercropping, all the interaction treatments had statistically similar effects on 100 seed weight of green gram. On the sole cropping side, Sole green gram planted at 80 cm row spacing gained statistically heavier 100 seed weight (4.5 gm) over sole green gram planted at 40 cm spacing (3.9 gm); however, it showed a similar effect with 60 cm spacing (4.1 gm).

The 100 seed weight of green gram in the wider row spacing was observed heavier due to better soil fertility and higher light availability for bean plants to grow vigorously. In line with the present result [30] observed insignificantly similar test weight of the seeds of the legume components in intercrop relative to sole stand agrees with the present finding. The results of the present study also agreed with the results of [14],[24],and [29]. Differently, [30]found hundred seed weight of haricot bean grown in differential mixture proportion intercropped with maize at two sites was observed insignificant effect compared to sole haricot bean.

3.1.8 Sesame grain yield

The combination of cropping system, row spacing, and variety had a significant impact on sesame output. Intercropped Setit1 varieties grown at 40, 60, and 80 cm row spacing all had varied effects on yield; at 60 cm spacing, the grain yield was significantly greater (5.9 q.ha-1) than at 40 cm (5 q.ha-1) and 80 cm (2.7 q.ha-1) spacing (Table 2). Grain yield was also affected differently by solitary setit1 planted at three-row spacing, with 40-cm spacing producing a much greater yield (6.9q.ha-1), followed by 60-cm spacing (4q.ha-1). Out of all the sets, the one planted at an 80 cm spacing produced the lowest yield (2.7q.ha-1).

The yield of local intercropping with green gram at 40 cm spacing, however, was significantly greater (4.3q.ha-1), and it was closely followed by 60 cm spacing (3.2q.ha-1).The fact that yields were generally higher than those of monocropping showed that intercropping was a practical method of improving the resource use efficiency of agroecosystems [31]. Local intercropping with 80 cm row spacing had the lowest significant yield (2q.ha-1).

Because sesame and intercrops compete more for resources, sesame intercropping treatments produced lower yields. The yield was significantly impacted when the most green gram rows (spaced 40 cm apart) were added between the sesame rows than when the lower rows (spaced 60 and 80 cm apart) were added.

The change in plant density, whereby wider row spacing plots were held with low plant densities compared to the tight rows, may be the cause of the yield decrease in sesame at wider row spacing for both cropping systems (sole and intercropped). A similar finding was published by [17], who found that the intercropping systems with green gram at varying row spacing had a substantial impact on the seed output of sesame.

Similar findings were also reported by [24], [26], [32], and [13]: of the intercropped treatments, sesame produced the most seed when planted with green gram at 60 cm row spacing, whereas sesame and green gram at 80 cm row spacing performed the worst.Y*ieldof sesame reduced* due to *intercrop* competition between *sesame* and *legumes*was alsomentioned by [33], [34] and [35]which supports this result.

3.1.9 Green gram grain yield

The grain yield of mung bean was sufficiently varied between cropping systems, row spacing and treatmentinteraction. The grain production of mung beans planted at 60 cm row spacing was considerably greater than the yield of the other spacing in the intercropped treatments of green gram and row spacing, whereas the least significant yield was seen when cultivated at 40 cm and 80 cm spacing. 60 cm spacing produced the maximum yield (6.7q.ha-1), while 80 cm spacing produced the lowest yield (4.6q.ha-1) (Table 2).

With regard to sole green gram and different row spacing, grain yield was affected differently. Sole green gram grown with a row spacing of 40 cm showed a significant maximum yield (13.2q.ha^{-1}) followed by when grown with 60 cm spacing (6q.ha^{-1}). However, sole green gram planted at 80 cm row spacing obtained the least grain yield (4.7q.ha^{-1}). In comparison to sole and intercropped grain yield of green gram, intercropping at narrow row spacing with both sesame varieties significantly lowered its yield; however, there was not significant yield reduction observed when intercropped at wider rows.

Compared to a single green gram, fewer yield characteristics may be blamed for the decreased yield of interplanted mung beans at close spacing. The tall, heavily branched sesame types may be the cause of the increased competition and suppressive effects. Regarding row spacing, the yield of green grams continues to decrease when the sesame population grows from 80 cm to 40 cm.

When one, two, or three rows of haricot beans were interplanted between rows of maize, the yield of haricot beans was reduced by 56, 44.5, and 28.2%, respectively, in comparison to haricot beans in a solo stand [30]. In a similar vein, [36] and [37] showed a more than 30% reduction in grain output per maize plant when compared to pure stand. According to earlier research on sesame crops by [38], plants with narrow spacing compete more for available resources, particularly light, and produce more than plants with wide spacing. This is consistent with the variation in grain yield of the intercrop between different row spacing of green gram in the current result. Similar findings were also reported by [24], [26], and [13]. In a related study, [39] discovered that the solo green gram crop, cultivated in single rows 40 cm apart, yielded a much higher amount of seeds than the intercrop, which was grown at varying planting densities. Plots where maize was interplanted with two or three rows of beans, as opposed to 1:1 row arrangements and maize alone, showed lower grain yield statistics, which is consistent with the current findings [40] and [41]. [42] It was also observed that the grain yield of the sorghum intercrop was much lower than that of the pure stand.

3.1.10 Land equivalent ratio

The Land Equivalent Ratio (LER), as explained in [42], is a crucial metric for determining the intercropping system's production. Variety, cropping system, and row spacing all interacted to produce a substantial variation in LER ($p<0.05$), as shown in Table 2. Intercropped setit1 at 60 cm spacing gained significantlythe highest LER value (2.6) and at 40 cm produced the least LER value (1.1). Intercropped setit1 at 80 cm produced an intermediate LER value (2.1) between the two and was significant. Local intercropped at 60 cm and 80 cm was significant to 40 cm with an LER value of (2.2), (1.96) and (1.2) respectively (Table 2). Compared to the LER values of the two varieties, setit1 intercropped with green gram at 60 cm spacing gained a significantly higher LER than intercropped local at 60 cm; all the other showed insignificant influence.

Land equivalent ratio values for intercropped setit1 and local at different row spacing showed that LER values were higher than one in all interactions which shows the advantages of intercropped over the sole cropping. To achieve the current yield of the component crops from the practice of solitary cropping, 2.6 hectares of land would be needed, according to the highest LER value of 2.6 obtained from intercropped setit1 at 60 cm. Sesame and mung bean intercropping was productive and had a yield advantage over growing alone, as indicated by the intercropping system's LER values being more than one. The gradient of resource input affects the relative importance of intercropping systems. The pattern of nutrient-induced facilitation in terms of yield and nutrient absorption changed in the intercropping systems [43].

Possible reasons for higher LER values resulting from intercropped and spacing interaction could be due to effective complementarities and resource utilization. Findings of [44] showed that higher LER in intercropping at various planting patterns was due to utilization of the natural (light, land) which agrees with the present result. Correspondingly, [28], and [45] reported higher LER values for intercropped treatments than sole in sesame sorghum intercropping. [46] It was also revealed that, when compared to their sole crops under varying row spacing, the intercropping system with the highest LER values was sesame pigeon pea intercropping. [47] reviewed the same findings, noting that the LER was higher with pigeon pea + sesame intercropping systems regardless of planting pattern, and [21] found that the highest LER (1.32) was obtained with sorghum + green gram intercrop row ratio and nitrogen, which led to the highest LER (1.32) at the intermediate 60 cm row spacing. [48] also discovered that the intercropping of pigeon peas, castor, and green grams had the highest LER (1.62 and 1.61).

Table 2: Interaction effects of cropping system and row spacing on number of pods per plant, number of seeds per plant, number of pods dropped per plant, yield and yield components of green gram

Method of Cropping	Row spacing 40 cm	60 cm	80 cm	40 cm	60 cm	80 cm
	Number of pod plant^{-1}			Yield (q/ha)		
Intercrop	19.2^{c}	31.9^{b}	34.0^{ab}	6.7^{b}	5.0^{cd}	4.6^{d}
Monoculture	36^{a}	35^{a}	35^{a}	13.2^{a}	6^{bc}	4.7^{cd}
	Number of seeds per pods			100 seed weight (gm)		
Intercrop	8.0^{c}	11.5^{a}	11.8^{a}	3.8^{a}	3.9^{a}	3.9^{a}
Monoculture	9.9^{b}	12.1^{a}	11.9^{a}	3.1^{b}	3.8^{a}	3.9^{a}
	Number of pod dropped plot^{-1}					
Intercrop	453.3^{d}	311^{d}	229^{d}			
Monoculture	5635^{a}	4294.6^{b}	3293.6^{c}			

3.1.11 Oil content of sesame

One of the quality criteria for sesame seeds is their oil content. The oil content of sesame ranges from 40 to 60%, depending on the variety and growth conditions, according to the Sesame Production Manual (2012). Wide-line nuclear magnetic resonance (NMR) at the Holeta Agricultural Research Center was used to determine the oil content in this investigation. The findings showed that the tested treatments' oil content was comparable to the previously established benchmarks. This result is in harmony with [49] who found a non-significant difference of oil content between intercropping and sole cropping sesame treatments. Similarly, [50] found insignificant differences of sesame oil content harvested from plots of different row spacing.

4 CONCLUSION

The current study found that when intercropping was planted at 40 cm row spacing, the number of pods per plant and the output of both mung beans and sesame decreased when compared to a pure stand. Sesame number of capsules per plant, green gram number of pods per plant, and green gram number of seeds per pod were significantly reduced when Setit1 and local sesame varieties interplanted with mung beans at 40 cm row spacing compared to all other interactions. However, Setit1 and local interplanted with green gram at 60 cm row spacing had statistically comparable gains with their resulting sole crops. There was no inter-specific rivalry because the grain yields of green gram and sesame were maximum in their respective sole cropping. A pure stand of green gram and sesame seeds spaced 40 cm apart yielded a grain yield that was significantly higher than all subsequent interactions. Sesame varieties both sole and intercrop, gained the lowest grain yield when grown at 80 cm row spacing. In the case of green gram intercropping both sesame varieties at 40 cm row spacing greatly decreased its yield relative to the wider rows. However, the interaction of intercropping and row spacing effectively managed green gram pod drops to a significant level compared to the sole interactions. Maximum and significant LER values were obtained when setit1(2.6) and local (2.2) sesame were intercropped with green gram at 60 cm row spacing over all other interactions and were significant between them.

5 RECOMMENDATION

In the study area, the productivity of sesame is constrained by insects and soil fertility problems due to sole cultivation of the crop year after year; in addition to the international price volatility of the commodity. Moreover, green gram is an emerging crop that is demanded widely in the global market and well adapted to the area, more productive than sesame, and needs low production cost. Farmers who grow sesame should practice growing green grams at row spacing of 40 cm to gain a higher return. Based on the findings of this research, sole green gram grown at 40 cm row spacing may be recommended for the areas of western Tigray.

6. REFERENCES

1. FOA (2016). Food and Agriculture Organization of the United Nations (FAO). 978-92-5-109374-0. http://www.fao.org/3/a-i6030e.pdf

2. Central Statistical Agency (CSA) (2018). The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Area and Production of Crops. Statistical Bulletin No. 586. Addis Abeba, Ethiopia

3. Sorsa, D.&Gelalcha. (2009). Sesame trade arrangements, costs and risks in Ethiopia: A baseline survey.

4. National Sesame Sector Development Strategy, 2014/15 & 2015/16). Ethiopia.

5. White, T.(2010). Green gram production and marketing constraints in Cambodia. Cambodian Agricultural Research and Development Institute: Cambodia; p 15-21.

6. Ramesh, K., &Thirumurugan, V. (2001). Effect of seed pelleting and foliar nutrition on growth of soybean. *Madras Agricultural Journal,* 88 (7-9):465-468

7. Wang, W., Li, M. Y., Zhou, R., Zhu, S. G., Tao, H. Y., Khan, A.,&Xiong, Y. C. (2023). Effects of interspecific interactions on soil carbon emission and efficiency in the semiarid intercropping systems. *Soil and Tillage Research*, *234*, 105857.

8. Humera Agricultural Research Center (HuARC) 2014. Unpublished report.

9. Mead, R., & Willey, R. (1980). The concept of a 'land equivalent ratio'and advantages in yields from intercropping. *Experimental agriculture*, *16*(3), 217-228.

10. MoARD (Ministry of Agriculture and Rural Development) (1998-2011). Crop Variety Registers Book.Addis Ababa, Ethiopia

11. Duncan, D.B. (1955) Multiple Range and Multiple F-Test. Biometrics, 11, 1-5.

12. Gupta, Singh S, Mahendra P, Singh, Sharma, R.,& Kaushik, S., K. (1994). Intercropping maize, sorghum and pearl millet with short duration grain legumes. *India J. Agric. Sci.,* 48: 132–40

13. Imoloame, E., O, Gworgwor, N., A.& Joshua, S., D. (2007). Sesame (Sesamumindicum L.) weed infestation, yield and yield components as influenced by sowing method and seed rate in a Sudan Savanna agro-ecology of Nigeria.*African Journal of Agricultural Research* Vol. 2 (10), pp. 528-533, October 2007, Available online at http://www.academicjournals.org/AJAR ISSN 1991- 637X

14. Meena, N, Sharma, K, Yadav, B.& Jana, B. (2015). Response of mungbean (*Vignaradiata L.*) to FYM and zinc 138 enriched FYM in loamy sand soil of Jobner: *Intern. J. Dev. Res*. 5(09): 5478-5482.

15. Sritharan, N.,&Senthilkumar, R. (2015) Physiological approaches: Yield improvement in blackgram: Leg. Res. 38(1): 9195.

16. Surendra, K., Vincent, S., Vanagamudi, M., &Vijayaraghavan, H. (2013). Physiological Effects of nitrogen and growth regulators on crop growth attributes and Yield of black gram (Vigna mungo L): *Bull. Env. Pharmacol. Life Sci.* 2(4): 70-76.

17. Dinesh Kumar, R.,Ardeshna, B.,Verma, B., and Patel, A. (2017). Growth and Yield Performance Of Summer Sesamum Based Intercropping Systems. *Int.J.Curr.Microbiol.App.Sci*. 6(6): 3341-3348. doi: https://doi.org/10.20546/ijcmas.2017.606.292.

18. Puste, A., Mandal, T., Gunri, K., Devi, S., %Pramanik, B. (2014). Growth, yield and intercropping under different moisture regimes in new alluvial zone of West Bengal: *Journal of Crop and Weed*, 10(1):19-24(2014).

19. Ashraf, A. (1997).Impact of inoculation, phosphorus and irrigation on biological efficiency of Green gram: Ph.D. Thesis, Deptt. of Agronomy, Univ. Agri. Faisalabad, Pakistan

20. Khan, M. (2000). Bio-economic efficiency of different cotton based inter cropping systems: Ph.D. Thesis, Deptt. of Agronomy, Univ. Agri. Faisalabad, Pakistan.

21. Deshpande,,R., Kharch,e S.,&Rawanker,H., N. (2002). Studies on intercropping with legumes in relation to planting pattern of hybrid cotton: *PKV Res. J.* 13: 100-104.

22. Rao, B., Sadaphal and Rao, M. (1993). Intercropping with green gram and cowpeas and its Residual effect on succeeding wheat crop: *Zeitchrift Fur AckerundPflamzemvau,*152(3): 199-207.

23. Rao, S., C. &Northup, B., K.(2009). Capabilities of four novel warm-season legumes in the southern Great Plains: grain production and quality. *Crop science,* 49 (3): 1103-1108

24. Subramanian,V. B.,& Rao, D, G. (1988).Intercropping effects on yield components of dryland sorghum, pigeon pea and mung bean. (145). (1988). *Tropical Agriculture,* 65(2). https://journals.sta.uwi.edu/ojs/index.php/ta/article/view/5395

25. Sharma, P., Singh, G., and Bains, T. (2014). Influence of foliar fertilization on sink strength, growth and grain yield in mungbean (Vignaradiata L Wilczek): *Eco. Environ. & Cons.*, 20(4): 16131617.

26. Arya, M., &Karala, G. (1988). Effect of phosphorus doses on the growth, yield and quality of summer mung (Vignaradiata L. Wilezek) and soil nitrogen.*Indian J. Agric. Res.*, 22:23-25.

27. Rajesh, K., Narender, R., Kumar, R., & Gopal, S. (2014). Effect of Plant growth regulating compounds on chlorophyll, photosynthetic rate and yield of green gram: *Intern.J. Develop. Res.,* 4(5): 1110-1112.

28. Wijnands, J., Biersteker, J.,&Hiel, R. (2007). Oilseeds Business Opportunities in Ethiopia: Survey report, Ministry of Agriculture, Nature and Food Quality, The Netherlands, The hague: Pp.8-20.

29. Bhatti, I., Ahmed, R., and Nazir, M. (2005) Agronomic traits of sesame as affected by grain Intercropping and planting pattern. Pakistan Journal of Agricultural Sciences, 42: 56-60.

30. Priyanka, S., Titare, Deotale R, Chore N., Balachandran, S., Kuchanwar, O., &Chopde, N. (2005). Effect of nutrients and hormones on yield and yield contributing Parameters of green gram: J. Soil. and Crops: 15(2): 419-423.

31. Zhu, S. G., Kiprotich, W., Cheng, Z. G., Zhou, R., Fan, J. W., Zhu, H., ... &Xiong, Y. C. (2023). Soil phosphorus availability mediates facilitation dynamic in maize-grass pea intercropping system. *Soil and Tillage Research*, *234*, 105867.

32. Tamiru,H. (2014). Effect of intercrop row arrangement on maize and haricot bean productivity and the residual soil: World Journal of Agricultural Sciences Vol. 2 (4), pp. 069-077, June 2014 Available online at http://wsrjournals.org/journal/wjas ISSN 2329-9312 ©2014 *World Science Research Journals*.

33. Chandrasekhar, C.,&Bangarusamy, U. (2013) .Maximizing the yield of mung bean by foliar application of growth regulating chemicals and nutrients: *Madras Agric. J.* 90 (1-3): 142- 150

34. Bhatt, B.K., Dixit S.K., and Darji V.B., 2010. Monetary evaluation of sesame based intercropping systems. Indian Journal of Agricultural Research (2): 146-149.

35. Yadav, P, N., Uttam, S, K., Singh, R, P., Katiyar, S, C., Tripathi, A, K., Kanaujia, D. K., (2013). Productivity, economic viability, water use efficiency, reciprocity functions and energy efficiency of sesame *(Sesamumindicum)-based* intercropping in rainfed ecosystem. Current Advances in Agricultural Sciences(An International Journal) Year : 2013, Volume : 5, Issue : 1 First page : (59) Last page : (63) Print ISSN : 0975-2315. Online ISSN : 2394-4471

36. Mandal, M., K. &Pramanick, M. 2014. Competitive behaviour of component crops in sesame greengram intercropping systems under different nutrient management. *The Bioscan*, 9(3): 1015-1018.

37. Silwana, T., T.& LUCAS,E., O. (2002). The effect of planting combinations and Weeding on the growth and yield of component crops of maize/bean and maize/pumpkin intercrops. The Journal of Agricultural Science 138(02):193 – 200 DOI: 10.1017/S0021859601001861

38. Morgado, L., B.& Willey, R., W. (2008). Optimum plant population for maize-bean intercropping system in the brazilian semi-arid region.*Crop Science Sci. agric. (Piracicaba, Braz.)* 65 (5) 2008 https://doi.org/10.1590/S0103-90162008000500005

39. Sharma, S. M.(1994). Sesame research and its progress in India. In:Oil crops-sesame and safflower, Omran A (ed.), IDRC Ottawa,pp. 11-27.

40. Iftikhar, H., Bhatti, R., Ahmad, A., Jabbar, Z., Abbas, V.,& Muhammad, A. (2008). Agro-economic performance of mungbean intercropped in sesame under different planting patterns: *Pak. J. Agri. Sci.,* Vol. 45(3).

41. Zama Q, Malik MA (2000).Ricebean (Vignaumbellata) productivity under various maize-ricebean intercropping systems. International Journal of Agriculture Biol., 2(3): 255-257.
659-665.

42. Mutungamiri, A., Mariga, I., &Chivinge, O. (2001). Effect of maize density, bean cultivar and bean spatial arrangement on intercrop performance: *Afr. Crop Sci. J.* 9(3): 487-497.

43. Undies, U., Uwah, D., Attoe, E. (2012). Effect of Intercropping and crop arrangement on yield and productivity of late season maize/soybean mixtures in the humid environment of southern *Nigeria: J. Agric. Sci.,* 4(4): 37-50.

44. Zhu, S. G., Zhu, H., Zhou, R., Zhang, W., Wang, W., Zhou, Y. N., &Xiong, Y. C. (2023). Intercrop overyielding weakened by high inputs: Global meta-analysis with experimental validation. *Agriculture, Ecosystems & Environment*, *342*, 108239.

45. Willey, R. (1979). Intercropping—It's Important and Research Needs. Part 1. Competition and Yield Advantages. *Field Crop Abstracts,* 32, 1-10.

46. Sarkar, R., K, &Chakraborty, A. (2000).Biological feasibility and economic viability of intercropping pulse and oilseed crops with sesame (*Sesamumindicum*) under different planting patterns in rice-fallow gangetic alluvial land. Indian Journal of Agricultural Sciences, 2000, Vol. 70, No. 4, 211-214.

47. Sarkar, R., K.,&Sanyal, S., R.(2000). Production potential and economic feasibility of sesame (Sesamumindicum L.) based intercropping system with pulse and oilseed crops on rice fallow land. *Ind. J. Agron.,* 45(3): 545-550.

48. Subbareddy, G.,&Venkateshwarlu, S. (1992). Effect of planting pattern on yield and moisture use efficiency in sunflower – pigeon pea intercropping system. *Indian J. Agronomy*: 37(4):

49. Srinivasulu, K., Singh, R., &Madhavi, K. (2000) Performance of rain fed pigeon pea based intercropping systems under varying planting patterns. Crop Res., 20: 56-61.

50. Omprakash and Bhushan, L.S. (2000). Productivity and economics of pigeonpea (Cajanuscajan) and castor (Ricinuscommunis) based intercropping systems. Indian Journal of Soil Conservation, 28: 147-150.

51. Gebre, Hadgu. (20060). The effect of planting methods and spacing on the yield and yield attributes of sesame (Sesame indicum L) in the low land plain of Humera, Western Tigray, Ethiopia (Unpublished Masters' thesis). Haremaya University, Ethiopia. Haile, M., Tesfaye, M., Tesfaye, A., &Mulat