Research on World Agricultural Economy
http://ojs.nassg.org/index.php/rwae

Comparative Study on Profitability of Sorghum-Legumes Intercropping Systems in Ethiopia

Dessalegn Ayana Deressa*

Assosa University, Department of Plant Science, College of Agriculture and Natural Resources, Assosa, Ethiopia

ARTICLE INFO

Article history
Received: 10 September 2021
Accepted: 27 September 2021
Published Online: 30 September 2021

Keywords:
Intercropping
Sorghum
Legumes
LER
Monetary value index

ABSTRACT

The imbalance between the crop production and population growth is currently the major issue in Ethiopia. To feed the growing population, increasing the production of food through growing more crop types in the same field as an intercropping is the right strategy. The study was aimed at evaluating the profitability of sorghum-legume intercropping on yield of sorghum. Intercropping sorghum with legumes crops increases the land productivity as its Land Equivalent Ratio is greater than one. In these cases, the land equivalent ratio is greater than one indicating the benefits of intercropping. In general, legume crops contributed to the yield of sorghum either intercropped with legume or grown up using residual contribution of legumes after a year. Therefore, for maximum sorghum production, farmers should plant either as intercrop or after residual effect of legumes crops. In addition to agronomic parameters used to compare the advantages of any cropping system in small scale farming conditions, total gross monetary value is also used to evaluate economic advantages of intercropping system.

1. Introduction

Intercropping is one of the commonly used cropping practices in most tropical areas in Africa. It is the growing of two or more crop species simultaneously in the same land during the growing season (Lithourgidis *et al.,* 2011). Shortage of the farm land due to population pressure forced to explore new ways to intensify production and productivity per unit area of land (Usmanikhail et al., 2012). Nasri et al. (2014) stated that the benefit of intercropping over sole cropping in terms of production per unit area. It is an attractive strategy to increase the productivity and land use efficiency (Seran and Brintha, 2010). Cereal-legume intercropping is the most commonly used practice by smallholder farmers in developing countries because of its environmental as well as economic advantages (Willey, 1979). It is also important for better use of resources, improvement of soil fertility, soil conservation and reduction of risks and suppression of weed infestation (Emam, 2003). However, the advantage of intercropping is obtained when correspondent species has differences in crop architecture, maturity time, nutrient use to optimize the use of natural resources and environmental factors when cropped together (Nurbakhsh et al., 2013).

Intercropping has an advantage and often provides higher economic benefit than mono cropping (Amanullah et al., 2006). Intercropping productivity and economic benefit was determined by using different evaluating indices. Land equivalent ratio (LER) and monitory advantage index (MAI) are the commonly used indices adopted in intercropping to evaluate intercropping advantages. LER is an indicator to determine the efficiency of intercropping (Kurata, 1986). The value of LER greater than one indicates that the greater efficiency of land utilization in

**Corresponding Author:*
Dessalegn Ayana Deressa,
Assosa University, Department of Plant Science, College of Agriculture and Natural Resources, Assosa, Ethiopia;
Email: ayanadessalegn074@gmail.com

DOI: http://dx.doi.org/10.36956/rwae.v2i4.450

intercropping due to greater efficiency of resource utilization in intercropping (Seran and Brintha, 2010). In general, in designing alternative crop systems, the common approaches to be followed are crop intensification, crop diversification and cultivar options. However, the three approaches become inseparable and considered as a building block of a new system (Yadav *et al*., 1998).

The main objective of intercropping has been to maximize use of resources, such as space, light and nutrients as well as to improve forage quality and quantity. Most researchers believe that intercropping system is especially beneficial to the smallholder farmers in the low-input and high-risk environments of the tropics (Rana *et al*., 2001). The principal reasons for smallholder farmers to intercrop are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed management and balanced nutrition (Shetty *et al*., 1995). Therefore, the objective of this paper is to review research findings and to compare and contrasting for putting future research direction in sorghum-legumes intercropping system profitability in Ethiopia.

2. Sorghum-Legumes Intercropping for Profitability

2.1 Intercrop of sorghum with pigeon pea and cow pea

The study is conducted in Yeki District of Sheka zone in Southern Nations Nationalities and Peoples Region. Intercropping sorghum with pigeon pea and cow pea resulted in a significant greater unit. For sorghum/ pigeon pea and for sorghum/ cow pea have 0.9 and 1.25 LER values respectively. LER greater than one is considered to be more efficient systems from a land use point of view than mono crops (Willey, 1979). Similarly Musambasi *et al*. (2001) reported that intercropping maize with different legumes at different locations resulted in greater LER for maize. This indicates that intercropping of sorghum with these legume crops gave advantageous yield than planting them in mono crop Table 1.

Table 1. First Year Land Equivalent Ratio for the Effect of Intercropping Sorghum with Legume

Treatments	Grain yield(KgH-1)	(LER)
Sole sorghum	3979.62	
sole pigeon pea	574.06	
sole cow pigeon pea	909.71	
sorghum intercropped with pigeon pea	1592.59	
sorghum intercropped with cow pea	1879.62	
pigeon pea intercropped with sorghum	135.18	0.9
cow pea intercropped with sorghum	430.55	1.25

Source: (Gebremichael *et al.,* 2019)

2.2 The long term effect of intercropping on yield and yield component of sorghum

The intercropping of legume on cereals particularly sorghum may accrue some selected nutrients particularly, Nitrogen to the soil which in turns to improve the soil fertility to benefit the subsequent crops. In the first year, all combination of sorghum with leguminous shrubs was evaluated at farm level. Next year, considering the advantage of leguminous shrubs to soil fertility, only sorghum as a test crop was evaluated with respect to yield and yield components after planting in the plot of pigeon pea, cowpea and under intercropped condition with legume. According to Carsky *et al*. (2001), cereal yield is usually higher after a legume crop than after a cereal crop.

The Table 2 depicted that 74.0% sorghum yield change was observed when planted under intercropped condition of sorghum with pigeon pea. It also observed that, planting sorghum under sorghum-cowpea intercropped condition maximize the yield of sorghum by 41.8%. However, the yield of sorghum planted under sole condition is decreased from 2379 kg ha^{-1} to 1995 kg ha^{-1}.

Table 2. The Long Term Effect of Intercropping Sorghum-leguminous on Yield and Yield Component of Sorghum

Treatments	Plant Height (cm)	grain yield (Kgha-1)
plot of Sole sorghum	226.2	1995^{c}
plot of sole pigeon pea	259.2	2885^{a}
plot of sole cow pea	228.4	255^{ab}
plot of sorghum intercropped with pigeon pea	227.6	2770^{a}
plot of sorghum intercropped with cow pea	228.3	2665^{ab}
Mean	**233.94**	**2573**
CV (%)	**17.62**	**30.36**
LSD (0.005)	**95.08**	**1800**

Source: (Gebremichael *et al.,* 2019)

The study of Pal and Sheshu (2001) reported the direct and residual contribution of legumes to the yield and N up take of maize and found that all the legume crops contributed to the yield of maize. Generally, using pigeon pea in rotational system is more profitable than using intercropping sorghum with cow pea.

2.3 Intercrop of sorghum with soybean and Groundnut for striga weed control

In traditional African cropping, prolonged fallow, crop rotation and intercropping were the common practices that

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kept Striga infestation in tolerable level. This parasitic weed cause estimated yield losses that range from 40 to 100% when the infestation is very serious, especially in northern, north western and western parts of the Ethiopia where sorghum cropping is the most suitable choice for farmers (Kidane, 2014). The intercrop of sorghum with soybean and Groundnut study is conducted on selected farmer's fields where striga infestations have been relatively higher at all cropping season. Therefore, intercropping of sorghum with soybean and groundnut research is used to control striga from sorghum field Table 3.

Both soybean and groundnut planted as pure stands recorded greater yield of (1190.1 kg/ha and 1115.3 kg/ha respectively) than that produced from intercropped with sorghum (Table 3). The higher yield of sole soybean and groundnut could be attributed to the least competition in pure stands.

In other intercropping research finding Ljoyah (2014) concluded that higher yield of soybean form sole cropping than that produced from intercropped soybean due to the shading effect of maize over soybean. Among the different intercrops higher grian yield was recorded by soybean (1123.2 kg/ha) when intercropped with sorghum in simultaneous single alternate row arrangements, followed by relay croppings of sorghum-soybean. Grain yield of groundnut was recorded relatively lower in intercropping with sorghum due to severe competition for growth resources.

2.4 Yield advantages of the intercropping

One of the main objectives of intercropping is increasing productivity per unit area. The productivity and benefit of the maize-common bean intercropping were evaluated by using land equivalent ratio (LER) and monitory advantage index (MAI), respectively. Land equivalent ratio (LER) is used for estimating advantages or disadvantages of intercropping over sole cropping system (Dhima et al., 2007). Based on the result, the intercropping treatments had higher LER than monoculture, which indicated the superiority of intercropping over sole cropping. Gross Monetary Value (GMV) was determined to evaluate the economic advantage of intercropping system as compared to sole cropping (Willey, 1979). GMV was computed from the yield of sorghum, and soybean and cowpea component crops by multiplying the yields with their respective unit price. The total values obtained from the component crops were used to indicate the Gross Monetary Value. According to Kinde *et al.(*2015), report to estimate the GMV of component crops, sorghum grain yield is valued at an average open market price of 7.00 ETB kg^{-1}, soybean and cowpea each at 4 ETB kg^{-1} at the time of crop harvest in Daro Labu District, West Hararghe.

Table 3. Yield of Sorghum, Soybean and Groundnut and Land Equivalent Ratio (LER) as Influenced by Cropping System and Row Striga Population in 2014 & 2015

Treatments	Grain yield (KgH-1)	(LER)	Number of Striga per m2 in 2014	Number of Striga per m2 in 2015
Sole sorghum	1481.2		8.00[a]	7.97[a]
Sole soya bean	1190.1		7.73[a]	6.37[ab]
Sole groundnut	1115.3		7.90[a]	6.10[ab]
Sorghum intercropped with soybean	1307.9	0.88	7.82[a]	4.57[b]
Sorghum intercropped with groundnut	1766	1.2	7.33[a]	6.37[ab]
Soybean intercropped with sorghum	1123.2	1.8		
Groundnut intercropped with sorghum	1010.4	2.1		
LSD(0.005)			NS	2.55

Source: (Fitsum *et al*., 2016)

3. Conclusion

The most important strategy to increase agricultural output is the development of intercropping system, which is tolerant to biotic and abiotic stresses. Sorghum grain yield is significantly affected due to effect legumes-sorghum cropping system. Under these scenarios intercropping gave high yield advantage over sole cropping. Intercropping sorghum with legumes provides significant seasonal control of *Striga* and enhanced grain yields. The general plant community interaction has no parallel interaction for sorghum-legume intercropping systems but

DOI: http://dx.doi.org/10.36956/rwae.v2i4.450

some legumes- sorghum have synergetic interaction in the pattern and most of the legume crops are interact as companion effect on the sorghum crop yield.

4. Future Line of Work

The following points are future direction of work in the area:

i. The research studies are should focus in different environments to assess the performance of the legumes in a range of soil types, *weeds* species and moisture stress.
ii. Introduce farmers in order to get huge monetary benefits along with better quality production by using intercropping legume with sorghum. The result of some study showed that farmers would earn more income from intercropping crops than growing crops in sole cropping.
iii. Generally, intercropping is also used as an additional option to farmers to increase land use efficiency.

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 DOI: http://dx.doi.org/10.36956/rwae.v2i4.450