**Advances in Environmental Biology**, 11(5) May 2017, Pages: 49-63

AENSI Journals

**Advances in Environmental Biology**

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/

# A Review On Maize- Legume Intercropping For Enhancing The Productivity And Soil Fertility For Sustainable Agriculture In India

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Received 8 January 2017; Accepted 28 April 2017; Available online 24 May 2017

**ABSTRACT**

The availability of land for agriculture is shrinking every day as it is increasingly utilized for non-agricultural purposes. World population is growing exponentially and it has to fulfill their food requirements. Under this situation, one of the important strategies to increase agricultural output is the development of new high intensity cropping systems including intercropping systems. Intercropping is a type of mixed cropping and defined as the agricultural practice of cultivating two or more crops in the same space at the same time. It increases in productivity per unit of land via better utilization of resources, minimizes the risks, reduces weed competition and stabilizes the yield. Several factors influence the intercropping such as maturity of crop, selection of compatible crop, planting density, time of planting as well as socio economic status of farmers and the region. In intercropping, land is effectively utilized and Land Equivalent Ratio (LER) is used to measure the productivity of land. Legume intercropping systems play a significant role in the efficient utilization of resources. Maize has reorganized as a component crop in most intercropping. Cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping. Maize-legume intercropping systems are able to lessen amount of nutrients taken from the soil in comparison to maize. Moreover, intercropping improves soil fertility through atmospheric nitrogen fixation from atmosphere (150 tons/year) with the use of legumes, increases soil conservation through greater ground cover than sole cropping. In this study, the work carried out by various researches in maize based intercropping are discussed. This work would be useful to the researchers who involves in this field.

**KEYWORDS:** Maize, Growth, Yield, Light interception, Nutrient use efficiency, Weed management, Nutrient transfer

## INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. Maize is cultivated throughout the world (58°N latitude to 40°S latitude) in an area of 179.9 m.ha across 165 countries with a production of 1013.6 m.t and average productivity of 5.63 t/ha. It is largely grown in USA, China, Brazil, Argentina, Mexico etc. The highest productivity of 10.73 t/ha was achieved in United States, which was followed by China (5.81 t/ha) and Brazil (5.4 t/ha). India occupies 7$^{th}$ position in respect of area and production [1].

In India, maize is the third most important food crops after rice and wheat. Maize is cultivated in an area of 9.3 million hectares with a production of 24.2 million tonnes and productivity of 2564 kg ha$^{-1}$ [2]. The major maize producing states are Andhra Pradesh (20%), Karnataka (17%), Maharashtra (11%), Bihar (9%), Tamil Nadu

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(8%), Madhya Pradesh (6%), Rajasthan (6%) and Uttar Pradesh (5%). The area and production of maize has increased remarkably from1950-'51 to 2014-'15. As a result of recent technological interventions adopted by the farming community, the productivity has significantly increased to the tune of 368.7 per cent from 1950-'51 to 2014-'15.

In Tamil Nadu, maize is cultivated in an area of 3.4 million hectares with a production of 18.30 million tonnes and the productivity is 5359 kg $ha^{-1}$ [3]. In Tamil Nadu, maize is grown in an area of 0.1 lakh ha during 1970-71 with an annual production of 0.2 lakh tonnes, mainly concentrated in Tanjavur, Pudukkottai and Trichy districts. Due to rapid increase in the demand of maize for poultry and animal feed and for industrial uses, and popularization of high yielding varieties and hybrids, the area under maize has increased to 3.4 lakh ha with a production of 18.3 lac t during 2014 - 15. The major maize growing districts are Perambalur, Toothukudi, Dindigul, Erode, Karur, Ariyalur and Salem and smaller area in Southern districts of Tamil Nadu.

Maize is one of the oldest human-cultivated crops grown in tropical and temperate regions of the world. The center of origin is believed to be the Mesoamerica region, at least 7000 years ago when it was grown as a wild grass called teosinte in the Mexican highlands [4]. Despite its high yield potential, it is giving low yields because of improper fertilizer management practices due to lack of appropriate information on fertilizer management and bio fertilizer application. Increasing productivity per unit area through agronomic management is one of the important strategies to increase the production of maize.

The importance of cereal grains in human nutrition is widely recognized, as they provide substantial amounts of energy and protein to millions people, especially in developing countries [5].

Intercropping is a common cropping system in developing countries such as India [6]. It is the practice of growing two or more crops at the same time during the same growing season on the same piece of land [7]. With the rapid population increase, the demand for food has been increasing while land availability has been declining. Thus, the only way to increase agricultural production is to increase yield per unit area [8].

In tropical regions, corn has been considered as the best component in most of intercropping system [9]. Intercropping has recently been recognized as a potentially beneficial system of crop production [10]. This cropping system increased total productivity per unit land, per unit time and improves the judicious utilization of the land and other resources on farm [10] reduces soil erosion and thereby helps to maintain greater stability in crop yield in okra/cowpea intercropping system [11].

Other advantages of intercropping include: insurance against crop failure thereby minimizing risk, better use of resources by plants of different heights, rooting depths and nutrient requirements and a more equal distribution of labour through the growing season [12] & [13]. Moreover, intercropping systems more efficiently used the growth factors because they capture more radiation and make better use of the available water and nutrients, reduce pests, diseases incidence and suppress weeds [14] and favour soil-physical conditions, particularly intercropping cereal and legume crops which also maintain and improve soil fertility [15].

Several scientists have been working with cereal- legume intercropping systems and proved its success compared to the monocrops [16] Some studies have indicated that intercropping was more productive than sole cropping because of the complimentary effect of intercrops such studies included amaranth with cowpea, cucumber with cowpea [11], maize with cowpea [16] and cassava with cowpea [17]

## *2. Intercropping system and its importance:*

Intercropping is an age old practice of growing simultaneously two or more crops on the same field such that the period of overlap is long enough to include vegetative stage [18]. Intercropping has been a regular practice followed by the farmers of India, Africa, Sri Lanka and Malaysia. Intercropping is mainly practiced to cover the risk of failure of one of the component crops due to vagaries of weather or pest and disease incidence. Yield advantages in intercropping system are mainly because of differential use of growth resources by component crops. The complementarity will occur when the growth patterns of component crops differ in time [19].

Intercropping of legumes in association with non-legumes helps in utilization of nitrogen being fixed by legumes in the current growing season, but also helps in residual build up of nutrients in soil [20]. Best utilization of nutrients, moisture, space and solar energy can be derived through mixed/intercropping system. According to [21] intercropping not only stabilizes crop production by reducing the impact of weather vagaries, but also increases cropping intensity considerably.

According to [22] crops having differing growth stages, pattern and duration, avoidance of competition for resources at peak stages in general make a suitable component crop for intercropping with pigeonpea.

Moreover, plant types differing in height, branching habit, canopy cover and crop duration decide the suitability for intercropping system. Intercropping is one of the preferred ways to increase productivity and intensify land use and also reduce the amount of herbicides and fertilizers applied [23]. The main aim of intercropping is to augment the total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labour etc., [24].

Intercropping practices have some benefits such as improving yield [25] & [26]. \and increasing biological activities in the soil, and decreasing pests [27]. A number of indices such as LER, crop combination ratio, real yield loss, financial advantage, and intercropping benefits have been proposed to describe competition within and economic advantages of intercropping systems [28] & [29].

According to [30] LER was superior in all intercrops implying that the productivity of corn-soybean intercropping has a higher RY advantage over sole cropping under the additive intercropping system.

*3. Effect of intercropping on maize:*

*3.1. Growth and growth components:*

An intercrop is generally grown to make best use of interspace which is not fully utilized by main crop in early growth periods. The intercrop may reduce or increase the yield of main crop, depending upon the species and spatial arrangement of component crops.

According to [31] found that there was drastic reduction in maize plant height, leaf area index in association with sunflower in 4:2 ratio. Among the treatment combinations, maize + greengram in 4:2 ratio recorded higher plant height and leaf area index. This was mainly due to complementary effect between base crop and intercrop. Greengram was a short statured crop and grew about 1/3 of the plant height of base crop maize and offered lesser resistance for maize growth.

A study at Faisalabad in which the maximum LAI (8.75), LAD (262.7 days) and CGR (15.04 g $m^{-2}$ $d^{-1}$) were recorded for cowpea grown in alternate rows of maize followed by cluster bean (LAI 8.14, LAD 244.3 days and CGR of 13.52 $gm^{-2}$ $d^{-1}$) grown in alternate rows with maize which was significantly greater than rice bean seeded in alternate rows with forage maize [32].

According to [33] in monoculture, maize yield per plant increased as planting density decreased from 100 000 to 50 000 plants $ha^{-1}$. At a density of 50 000 maize plants $ha^{-1}$, both dry weight yield per plant and shoot N concentrations of maize were greater when intercropped with 50 000 Type III (bush-type) bean plants $ha^{-1}$ than in monoculture (196.4 g $plant^{-1}$ and 167.0 g $plant^{-1}$; 21.6 g N $kg^{-1}$ dry mass and 17.4 g N $kg^{-1}$ dry mass, respectively), but intercropping Type IV (climbing) beans at this density combination had no effects on either maize plant weight or shoot N concentration.

The results of a field study conducted at Faisalabad revealed that the cultivation of maize alone with full dose of nitrogen showed the maximum height (216.5cm), which was followed by maize intercropped with cowpea and N at 225 kg $ha^{-1}$ having plant height of 213.7 cm [34].

A field study to investigate the effect of cropping systems and N-fertilization on growth of corn and peanut grown in sole and inter-cropping systems. Results revealed that significant increase in plant height (190.93 cm) and LAI (2.26) were achieved when corn and peanut were intercropped in alternated furrows (2:1) with 80 kg $ha^{-1}$ urea [35].

A field experiment was conducted in Brazil to evaluate the influence of intercropping and row spacing on maize yield. Plant height, height of first ear, and number of grains $ear^{-1}$ were higher with the narrow row spacing. Maize grain yield was similar in both crop management types (10 301 and 9745 kg $ha^{-1}$ for monoculture maize and intercropped, respectively) [36].

According to [37] intercropping reduced the number of leaves per plant (5.11) and increased the height of okra plants (77.17 cm) irrespective of the manure rates which could possibly be attributed to the adequate nutrient supply that encouraged plant growth.

*3.2. Yield and yield attributes:*

According to [38] & [39] concluded from their studies that intercropping of soybean with maize did not reduce yields compared to maize alone. The plant height and days to maturity of maize in intercropping and sole cropping systems was not affected significantly.

Intercropping of maize with urdbean significantly increased the grain yield of maize compared to sole maize grown both in normal row planting and paired row planting [40]. Intercropping of legumes viz., soybean, cowpea, frenchbean and urdbean with maize at varying levels of NPK to legume components revealed that application of 50 % recommended dose of NPK to legume component was statistically on par with 100 % fertilizers. On an average, available soil N at harvest in intercropping system was higher by 30 kg N $ha^{-1,}$ maize equivalent yield by 15 to 20 q $ha^{-1}$ and LER by 30 to 37 % as compared to sole stand [41].

Higher maize grain equivalents were recorded with maize + soyabean whereas maximum grain yield of 32.48 q $ha^{-1}$ was recorded in maize + mashbean system [42]. Nitrogen application to intercropping systems improved growth, yield, yield components, maize equivalents and remunerative benefits in maize + legumes.

According to [43] sole maize was significantly superior to maize + cowpea and maize + okra intercropping treatments in respect of green cob and stover yield. However, the highest values of maize equivalent yield were associated with maize + cowpea which were significantly superior to maize + okra and sole maize. According to [44] the highest yield was achieved from sole maize compared to its combination with groundnut and soybean and same results were noticed in case of sole groundnut. Crop competition was possibly the main reason for reduction in yields.

According to [45] the maize-legume intercropping was studied to see the effect of legume on maize productivity grown in different geometrical patterns. The treatments tried were sole maize, maize + blackgram, maize + mungbean and maize + cowpea at different planting patterns, i.e. $P_1$=90 cm apart double row strips (80/90 cm) and $P_2$=120 cm apart triple row strips (80/120 cm). Maize grain yield was significantly greater in sole maize compared to other treatment combinations; while maize + cowpea intercropping gave minimum yield. Maize grown under $P_1$ provided the maximum yield of 39.38 q $ha^{-1}$.

Alternate planting combinations of maize *(Zea mays* L.*)* with common bean *(Phaseolus vulgaris* L.*)* or cowpea *(Vigna sinensis* L.*)* were compared with the solitary planting of each crop under the East Mediterranean conditions in Turkey. The highest maize seed yield was obtained from 1- row 67 maize: 50 cowpea mixture while the lowest one was from 2-row 100 maize:50 cowpea mixture. The highest legume seed yield was from sole planting and the lowest one was from 2-row 100 maize: 50 cowpea mixture [46]. According to [47] the intercropped treatments, four rows groundnut in between paired rows of hybrid maize var. Pacific-11 showed higher maize equivalent yield (15.34 t $ha^{-1}$), groundnut equivalent yield (4.91 t $ha^{-1}$), and land equivalent ratio (1.66) as compared to other treatments.

The results of a study conducted at Nigeria showed that higher grain yield was obtained from sole cropping plots while intercropped plots at mix proportion of 100 Maize: 100 Cowpea gave higher intercrop total grain yield of 2.81 t $ha^{-1}$. The highest intercropped maize yield was from 1 Maize:1 Cowpea plots with mix-proportion of 50 Maize:50 Cowpea while the highest intercropped cowpea grain yield was obtained from 100 Maize:100 Cowpea plots [48].

According to [49] intercropping of maize and peanut in different planting ratios significantly affected the yield. The highest dry biological yield of maize (57 t $ha^{-1}$) was obtained by sowing the crops in intercrop of maize 75 % + peanut 25 %. The highest grain yield (10.0 t $ha^{-1}$) of maize was recorded from sole maize (100 % maize + 0 % peanut) and the highest dry biological yield for peanut (7.4 t $ha^{-1}$) was recorded from intercrop of maize 50 % + peanut 50 %. Increase in grain yield of maize under sole cropping in maize-okra intercrop [50]. The combined yields of green maize and beans in the intercropped system were better than the sole yield of either of the two crops [51].

According to [52] simultaneous sowing of maize + fodder cowpea at 1:1 row proportion recorded significantly higher grain yield (5349 kg $ha^{-1}$) and stover yield (7581 kg $ha^{-1}$) over all other intercropping treatments except, maize sown after 1 week at 1:1 row proportion. The results are confirmed with the findings of [53] & [54].

According to [55] the green ear yield and total dry biomass of maize were significantly affected by nutrient management, but not by the intercropping system. This shows that the presence of soybean did not adversely affect the growth of maize. The present result is supported by that of [56] non-significant difference between monocropped maize and intercropped maize with soybean on yield and yield components.

*3.3. Effect of intercropping on light interception/light transmission ratio:*

According to [57] the two ratios viz., 2:2 or 4:2 of soybeans cv. Crawford intercropped with maize cv. Giza-2, 4:2 ratio received more light than 2:2 ratio. The alternate paired row spatial arrangement of maize-soybean intercropping system provided more light to soybean without declining the desired utilization for the light [58].

According to [59] minimum light transmission of 3.8 % was recorded under sorghum + fodder cowpea. The intercrop (fodder cowpea) of sorghum without fertilizer filtered maximum light of 54.6 % to the ground.

Two factors that affect yield in relation to incident radiation in an intercropping system are the total amount of light intercepted and the efficiency with which intercepted light is converted to dry matter [60]. For instance, according to [61] the radiation intercepted was higher in maize-bean intercropping than of the sole crop. Intercropped bean with maize had 77 percent higher RUE than sole-cropped beans [62]. According to [63] maize – soybean intercropping had better use of solar radiation over the monocrops.

According to [64] sole soybean was very effective at intercepting light, $f$ being 0.99 from 84 DAS onwards, whilst sole maize intercepted an average of 0.79 of incident photosynthetic photon flux density during the season. However, the canopy of sole soybean was less effective at intercepting light early in the season, $f$ *being* 0.41 at 56 DAS.

With respect to [65] the percentage of PAR interception was significantly ($P \leq 0/05$) affected by cropping system over sampling dates. At 55 days after sowing (DAS) the percentage of PAR interception by sole cropped cowpea and intercrops were not significantly different, with the lowest PAR reception being recorded by sole cropped corn. At 70 DAS, the percentage of PAR interception by intercrops treatments were significantly ($P \leq 0/05$) greater than either sole crop. PAR interception by sole cropped cowpea was significantly greater than that of sole cropped corn at 70 DAS.

Intercropping high and low canopy crops is to improve light interception and hence yields of the shorter crops which have to be planted between sufficiently wider rows of the taller ones [66]. According to [67] the MBILI (modified intercropping) system increased maize and legume yields through higher light penetration.

Percentage of solar radiation interception was significantly ($P \leq 0.05$) affected by various intercropping with different row proportion. The higher solar radiation interception was recorded on 1:5 maize + cowpea intercropping followed by 1:5 maize + cowpea over sole maize. However, the interception recorded was higher on all 1:5 crop combinations followed by 1:2 and 1:1. Along with this, the solar radiation interception was higher at 75 DAS over 50 DAS [68].

According to [69] the mean of PAR interception averaged over sampling dates by intercrop treatments was significantly ($P<0.05$) higher than that for sole crop systems. The mean percentage of PAR interception for intercrop treatments with additive design was also higher than that for intercropping with replacement design and sole maize. The mean PAR interception averaged over cropping system increased upto 85 DAS and then, declined.

The maize sown after 3 weeks at 1:2 row proportion recorded significantly lower (Light Transmission Ratio (LTR) (9.15 %) and higher light absorption (90.8%) compared to all other intercropping treatments [70].

*3.4. Effect of intercropping on nutrient use efficiency:*

Increased nutrient uptake in intercropping systems can occur spatially and temporally. Spatial nutrient uptake can be increased through the increasing root mass, while temporal advantages in nutrient uptake occur when crops in an intercropping system have peak nutrient demands at different times [71]. In the species that have different rooting and uptake patterns, such as cereal/legume intercropping system, more efficient use of available nutrients may occur and higher N-uptake in the intercrop have been reported, compared monocrops [72].

According to [73] the acquisition of P by the legume was markedly greater than that by the grass, regardless of the P form being inorganic or organic. The results indicate that wheat is less able to use organic P than inorganic P, whereas chickpea is able to use both P sources equally effectively. When wheat and chickpea were grown together, the following may have happened. Firstly, chickpea can mobilize and absorb some organic P by releasing phosphatase into soil, and also leave some inorganic P for wheat. Secondly, wheat with a greater competitive ability acquires more P from the root zone of both wheat and chickpea, resulting in P depletion in the chickpea rhizosphere [74].

Nitrogen uptake by intercropping of wheat and maize was greater than that by corresponding sole cropping under same supply [75]. According to [76] sole sorghum recorded higher nitrogen (75.7 kg/ha), phosphorus (18.8 kg/ha) and potassium (50.1 kg/ha) uptake than single intercropping with redgram and double intercropping either with redgram + soybean or redgram + coriander systems. According to [77] in a field experiment consisting intercropping of pearl millet with pigeonpea and castor reported that the N and P uptake by pearl millet was significantly influenced by cropping systems. The N and P uptake was maximum with sole pearl millet as compared to intercropping with pigeonpea and castor.

According to [78] an experiment consisting intercropping of maize + groundnut in different row proportions reported that maize + groundnut in 2:2 row proportion resulted in higher uptake of NPK than maize + groundnut in 1:1 row proportion.

Some studies conducted outside the Sub-Saharan Africa region have proven the comparative efficiency of intercrops to monocrops. For instance, maize and cowpea intercropping is beneficial on nitrogen poor soils [79]. According to [80] maize-cowpea intercropping increase the amount of nitrogen, phosphorus and potassium contents compared to monocrops of maize.

Despite the beneficial effects of the intercropping to the cereal crops, it may also accelerate soil nutrient depletion, particularly for phosphorous, due to more efficient use of soil nutrients and higher removal through the harvested crops [81]. However, according to [82] maize intercropped with soybean produced significantly lower NPK depletion and higher N uptake. Recent efforts on replenishment of soil fertility in Africa have been through the introduction of legumes as intercrop and/or in rotation to minimize external inputs [83].

According to [84] all soil nutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sodium) were low before the onset of experimentation and were largest in the maize-soybean intercropped plot compared to the quantities recorded in pure maize plot.

*3.5. Effect of intercropping on weed management:*

It is often believed that traditional intercropping systems are better in weeds, pests and diseases control compared to the monocrops, but it must be known that intercropping is an almost infinitely variable, and often complex, system in which adverse effects can also occur.

Intercropping of cereals and cowpea has been observed to reduce striga infestation significantly [85]. This was attributed to the soil cover of cowpea that created unfavorable conditions for *striga* germination [86]. According to [87] maize-bean intercropping reduced weed biomass by 50-66 % when established at a density of 2,22,000 plants $ha^{-1}$ for beans equivalent to 33 % of the maize density (37,000 plants $ha^{-1}$).

Field experiment was conducted at Udaipur to evaluate the uptake of major primary nutrients by maize legume intercropping system under the influence of weed control. Results revealed that maize + cowpea and maize + soybean were at par with each other during both years and found statistically superior over maize + blackgram, maize + green gram and sole maize in reducing monocot, dicot and total weed dry matter. On mean basis maize + cowpea and maize + soybean reduced the monocot, dicot and total weed dry matter by 33.4 and 37.5; 32.2 and 37.4 and 33.2 and 37.5% , respectively, compared to weed check [88].

According to [89] intercropping of cowpea and French bean reduced the weed population and weed dry weight significantly than sole cropping and maize + coriander intercropping system. Maize + frenchbean (1:2) showed the highest MEY and productivity and maize + cowpea (1:5) recorded the lowest weed count and weed dry weight and the highest weed control efficiency.

According to [90] weed dry weight recorded at all the stages of crop growth was significantly influenced by different intercropping systems and it was reduced under the intercropping of maize with soybean and greengram, while it was higher with maize sown as sole crop. Weed smothering efficiency (%) calculated at 20 and 45 DAS and at harvest clearly indicated that intercropping of maize with soybean registered higher weed smothering efficiency (WSE) than maize with greengram.

A study conducted at Agricultural University Peshawar indicated that maize intercropping with soybean and mungbean in different combinations significantly affected weed density ($m^{-2}$). The maximum number of weeds (166.3 $m^{-2}$) were recorded in control (weedy check) plots followed by plots where maize was intercropped with one row of mungbean seeded simultaneously (136 $m^{-2}$) which was statistically at same level with all treatments except maize hand weeded (45 $m^{-2}$), sole maize (83 $m^{-2}$) and maize intercropped with two rows of mungbean simultaneously seeded in which lower number of weeds were recorded [91].

The results of the field study conducted by [92] at Nigeria revealed that weed biomass in sole cropping pattern of okra was significantly greater than in intercropping pattern with maize and pepper. The sole okra cropping pattern (control) had the highest weed biomass (330.23 $gm^{-2}$). The mixed intercropping pattern had the least weed biomass of 185.2 $gm^{-2}$. Weed smother efficiency (WSE) was the highest in mixed pattern in both years compared to the other forms of intercrop pattern.

According to [93] lower density of sedges (19.72/$m^2$) and weed dry matter (18.93 g/$m^2$) were recorded in maize intercropping with cowpea and application of pendimethalin at 1.0 kg/ha as pre emergence. The lowest weed density and weed fresh biomass (24.45 $m^{-2}$ and 1100 kg $ha^{-1}$, respectively) were recorded in 10 rows mungbean + 6 rows maize and highest weed density (36.88 $m^{-2}$) and weed fresh biomass (2389 kg $ha^{-1}$) were found in sole maize treatments [94].

### *3.6. Evaluation of intercropping systems:*

Among crop mixtures land equivalent ratio (LER) is used for estmating advantages or disadvantage of crop mixture over sole cropping systems [95]. There are different competition functions like actual yield loss (AYL), land equivalent ratio (LER), competitive ratio (CR), relative crowding coefficient , intercropping advantage and monetary advantage index for evaluation of system efficiency and financial benefits of intercropping systems [96]. For maize + bean intercropping, these indices have not been used to find out the economic advantages, resource use efficiency and competition among species of intercropping system. Intercropping in cassava was beneficial in increasing the biological yield, tuber equivalent yield and land use efficiency. Cassava tuber equivalent yield, LER, ATER and AHER were higher in cassava + cowpea combinations compared to respective sole cropping [97]. According to [98] & [99] also recorded higher LER in maize based intercropping systems compared to respective sole cropping.

According to [100] an experiment was conducted to determine whether intercropping increased production for small scale farming in a semi-arid region (Freestate, South Africa). Crop productivity of maize and bean intercropping systems was evaluated in terms of crop yield and growth. The total LER for yield and growth ranged between 1.06 to 1.58 and 1.38 to 1.86, respectively showing yield and growth advantage of intercropping.

Maximum land equivalent ratio (1.29) was obtained under 120 cm spaced triple row strip + mashbean and minimum LER (1.09) was observed in maize at 60 cm spaced row + mungbean . Maximum maize seed yield (6.7 t $ha^{-1}$) and LER (1.62) was recorded in 90 cm spaced double row strips, maize + soybean intercropping [101].

According to [102] compared planting combinations including common bean *(Phaseolus vulgaris* L.*)*, maize *(Zea mays* L.*)* or cowpea to determine system efficiency and reported that 67:50 plant densities for both maize-common bean and maize-cowpea intercropping was found beneficial in terms of land use efficiency owing to its better yield and monetary benefits compared to respective sole planting irrespective of planting patterns. Land Equivalent Ratio (LER) values were greater than one in all intercropping systems with different planting ratios which indicated yield advantage of intercropping over sole cropping of maize [103].

According to [104] the maximum LER (1.89) in maize intercropped with cowpea and N at 225 kg $ha^{-1}$ which was followed by maize intercropped with cowpea and N at 200 kg $ha^{-1}$ (1.78). According to [105] LER was greater than unity, implying that it will be more productive to intercrop maize-soybean than grow them in monoculture.

A field study conducted in Nigeria revealed that LER for maize was above 1.0 in maize: cowpea mixture proportion of 50M:50C and 60M:40C while it decreased when the maize was more than 60%. The intercropped cowpea had higher relative crowding co-efficient (K) values than the intercropped maize. The K value for cowpea increased when the proportion of cowpea in the intercrop mixture increased and the K value was higher than 1 in mix-proportion of 100M:100C. Negative K values for maize were obtained in all intercropped mixtures [106]. According to [107] the highest LER was obtained from cropping system of 75% maize + 25% green gram with LER of 1.42.

The highest LER was obtained by sowing the crop in a ratio of intercrop of maize 50% + peanut 50% (2.30) and the lowest LER was obtained by sowing the crops as intercrop of maize 25% + peanut 75% (1.27). LER values were greater than one in all intercropping systems which indicated yield advantage of intercropping [107].

Among intercropping treatments, the higher LER and ATER (1.53 and 1.25, respectively) was noticed in simultaneous sowing of maize + fodder cowpea (1:2) over all other intercropping treatments [108]. Higher productivity, profitability and Monetary Advantage (MA) in maize/soybean intercropping system were positive, when compared to monocropping [109]. This result is in agreement with [110] who reported higher yield and monetary advantage index (MAI) for maize/soybean intercropping under a combined application of organic and inorganic fertiliser.

According to [111] corn and soybean had higher relative yield when grown in intercrop than when grown as a sole crop and the best relative yield total was at the 50:50 ratio of corn and soybean. According to [109] found that the LER of intercropping was more than one in all nutrient management samples, indicating the yield advantage of maize-soybean intercropping over monocropping. This result is supported by the scientist [112] who explained that the greater LER could be attributed to the morphological differences of the two crops and the optimal utilisation of resources.

*4. Nitrogen transfer in cereal-legume intercropping systems:*

The evidence for the direct transfer of N from the root system of a legume to that of an associated non-legume via rhizo deposition or mycorrhizal connections is contradictory. Much of the evidence in its support has come from research on mixed grass/legume swards, which persist in the field for much longer periods of time and whose root systems are often more closely associated than in most intercropping systems [113]. This N-transfer is considered to occur through root excretion, N leached from leaves, leaf fall, and animal excreta if present in the system [114].

According to [115] there is little or no current N transfer in cereal-legume intercropping system. In addition, [116] reported that benefits to associated non-leguminous crop in intercropping systems is influenced by component crop densities, which determine the closeness of legume and non-legume crops, and legume growth stages.

Despite claims for substantial N-transfer from grain legumes to the associated cereal crops, the evidence indicate that benefits are limited [117]. Benefits are more likely to occur to subsequent crops as the main transfer path-way is due to root and nodule senescence and fallen leaves [118].

According to many scientists [119], [120] & [121] there was evidence of direct transfer of fixed-N to cereal component in many controlled studies. Similarly, the scientists [122] & [123] have reported that mineralization of decomposing legumes in rhizosphere could enhance nitrogen availability to cereal crop. In intercropping systems, when configurations of rows are wider then rate of nitrogen transfer is relatively low resulting lower nitrogen fixation activity by legumes legumes [124]. For soil nitrogen, there exist competition and transfer from legume to non-legume in intercropping system [125] sometimes there happen bi-directional nitrogen transfer [126].

According to [127] the early stages of growth (4 and 6 WAP), N transfer by pigeon pea via below-ground process was 0.39 % and 0.53 % respectively, while N released from litter return was 0.99 % and 0.90%, respectively. During the same period N transfer due to interaction of above and below-ground processes was 0.15 % and 0.14 %, respectively. At maturity (8 and 10 WAP), 0.60 % and 0.09 % of N were transferred from pigeon pea to maize via below-ground process, while N released through litter return from pigeon pea leaf biomass was negative (-0.08 % and - 0.12 %, respectively).

The results of $^{15}$N labeling showed that *Glomus mosseae* and rhizobium SH212 inoculation alone enhanced the N transfer from soybean to maize in a soybean/maize intercropping system. The amount of N transferred from soybean to maize ($N_t$) of SH212+ *Glomus mosseae* were 11.45 and 12.46 mg more than that of NI, and it was also significantly more than SH212 or *Glomus mosseae* alone in mesh barrier and no barrier patterns [128].

The study was $^{15}$N-aided and made outdoors in basins (30 L) filled with 38 kg of soil. The results reported that in maize - based intercropping the proportion of N derived by maize from the associated legume varied from 7-11% for mungbean, 11-20% for cowpea and 12–26% for groundnut which amounted to about 19-22, 29-45 and 33-60 mg N maize plant$^{-1}$, respectively [129] & [130].

*5. Residual effects of cereal-legume cropping system:*

The intercrop legume may accrue N to the soil and this may not become available until after the growing season, improving soil fertility to benefit a subsequent crop [131].

According to [132] intercropping of cowpea with millet may enhance millet grain yields by 30 percent above the control. According to People and Herridge (1990) to maximize the contribution of legume N to a following crop, it is necessary to maximize total amount of N in legume crop, the proportion of N derived from $N_2$ fixation, the proportion of legume N mineralized and the efficiency of utilization of this mineral N.

According to [133] sunnhemp (*Crotalaria juncea),* tephrosia (*Tephrosia vogelii)* and velvet bean (*Mucuna pruriens*) green manure often resulted in maize yields of 3-6 t ha$^{-1}$ even with no addition of mineral N fertilizer. Moreover, Chibudu (1998) found that maize yields were increased by about 25 % and 88 % after maize-mucuna and maize-cowpea intercropping stems, respectively.

According to the scientist [134] maize yields were increased by about 244 % after maize-*Se*ing system. They found that maize grain yield was 28 % higher one year of soybean and 21 % higher after one year of cowpea than in the continuously cropped maize. Maize grain yield was 85 % higher after two years of soybean, and 66 % higher after two years of cowpea than in the continuously cropped maize.

According to [135] over 4 consecutive cropping seasons, grain yields of maize increased by 340 % in gliricidia-maize intercropping, when compared to unfertilizednole maize. Unfortunately, it is not always possible to optimize these factors. Beans with phosphorus fertilization increased grain yield of succeeding wheat by 20% over sorghum [136]. Soybean increased the grain yield of the following wheat by 44.9% in the non N-fertilized and 14.5-14.7% in the N-fertilized treatment [137]. Furthermore, the scientist [138] found that maize grain yield was 46 % significantly higher when grown after soybean than after maize and natural fallow.

According to [139] incorporating stover of Bambara nut, cowpea, groundnut, dry bean and soyabean gave higher maize yields compared to plots where the stover was removed. Total maize dry matter yield increases of 1.30 t ha$^{-1}$ to 5.19 ha$^{-1}$ were recorded following legume stover incorporation compared to stover removal. Even removal of stover of these same legumes gave significant maize yield increases compared to those from the maize after maize or after fallow plots. The total maize dry matter yield was greater after legumes with stover removed (ranging from 4.41 to 9.91 t ha$^{-1}$) than after maize (2.16 to 2.26 t ha$^{-1}$) or one season fallow (1.57 to 1.84 t ha$^{-1}$).

The plant height, fresh forage yield, dry matter yield, crude protein content and yield of oats was significantly higher owing to the previous *Sesbania* and cluster bean and least after millet [140]. Among the different legumes (cowpea, *Sesbania*, mung bean and fallow plots) grown as preceding crops followed by succeeding maize, the *Sesbania* grown plots had higher grain yield (5104 kg ha$^{-1}$) followed by cowpea and mung bean. Whereas the lower grain yield (3184 kg ha$^{-1}$) was observed in Fallow plots [141].

From the foregoing review, information pertaining to intercropping of hybrid maize varies widely. In maize, the effect of intercropping on growth and yield parameters, light transmission ratio, weed management, nutrient uptake and nutrient transfer in intercropping system, evaluation of intercropping system and residual effect on cereal-legume intercropping is well documented. Summarizing the review undertaken, it is understood that the potential productivity of hybrid maize could be achieved when it is grown under intercropping situations with varied crop management practices and it improves soil fertility through atmospheric nitrogen fixation with the use of legumes. In this context, the present investigation would pave way to improve the productivity of maize under intercropping system in order to get higher profit under irrigated condition.

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