REVIEW ARTICLE

Four 'Bio' Traits Craft Pigeonpea (*Cajanus Cajan* (L.) Millsp) to Survive in a Dry Soil Environment under Intercropping Situation -A Review

Swaminathan Chitraputhirapillai*, P. Kannan, N. Krishnaprabu, M. Mohammed Yassin

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Abstract

The climate of the rainfed tropics is complex in nature and intercropping aids in reducing the great peril of cropping under such conditions. Dryland or rainfed crops produce low economic yield and soils are eroded with diminishing soil fertility, hence it is timely to select an anchor crop for intercropping situations by reviewing various research publications.

This work has been carried out at the Agronomy Department, Agricultural College and Research Institute, TNAU, Madurai India. A methodical cum integrative review of past work done elsewhere, particularly in India was figured out. Nearly 200 research articles were scanned from different databases and 112 papers were utilised to write this review.

This review article comprehensively documents the uniqueness of pigeon pea, being a long-duration legume having advantages like soil fertility enhancement, multiple harvests, *etc.,* over annual short-duration crops and how it could be called an anchor crop under intercropping systems. And hence, the inclusion of drought-resilient pigeon peas for sustaining soil health and farm productivity under intercropping systems in semi-arid alfisol would be ideal.

Keywords: Pigeon pea, Bio-irrigation, Bio-ploughing, Bio-pumping, Bio-littering, Intercropping, Anchor crop

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Introduction

Rainfed areas in the Indian subcontinent are highly diverse, and most areas are resource-constrained and dry, where farming is the sole livelihood provision system and survival mechanism, rather than a growth-oriented activity. They experience a broad range of agroclimatic conditions, soil types, and rainfall pattern altering from 400 to 1600 mm per year. Protracted dry spells can end up in partial or total failure of crops, leading to a high threat to cropping. The best risk-reducing alternative in these regions is adopting intercropping, which executes several functions, including ecosystem services; food, and feed production, from the same land. It also ensures biodiversity through a blending of arboreal and herbs, with a life span ranging from few weeks to months, which includes annual herbaceous plants raised mainly to produce cereals, millets, legumes, oilseeds, etc. for human and animal consumption (Gaba *et al.,* 2014). The growth and productivity of food crops in semi-arid India are greatly impacted by the erratic distribution of monsoon rains. The inclusion of redgram as an anchor crop and other millets as component crops improve soil fertility and boost farmer's net income. According to estimates, the nation's current need for legumes is 22.5 MT. The demand for legumes in the nation is anticipated to reach 32 MT by the year 2030 and 39 million tonnes by 2050, taking into account trends in the population growth rate and the fact that several other options besides legumes are now available to meet people's protein needs as a result of changing dietary habits of the masses. It takes a tremendous shift in research, technology generation, its diffusion and commercialization, and capacity building in frontier areas of research to achieve this, which demands an annual growth rate of 2.2%. So, by scouring a variety of research, this review paper highlights the essence of the benefits and significance of pigeonpea as an anchor crop for semi-arid situations.

Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai- 625104, Tamil Nadu, India

***Corresponding author:** Swaminathan Chitraputhirapillai, Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai- 625104, Tamil Nadu, India, Email: swaminathanc@tnau.ac.in

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Methodology

The review work was carried out at the Agronomy Department, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India. From February 2020 to August 2020, nearly eight months were spent collecting literature, including two months for manuscript writing. About 200 scientific papers were screened, shortlisted, and 112 papers were used to prepare this manuscript. For the searching of research papers, various databases were used.

Intercropping Systems

Intercropping, a component of multiple cropping systems accommodates minimum two crops cultivated concurrently in the same field, which results in efficient usage of resources, causes constant yields at minimum risks and a technique to reduce difficulties with plant pathogens, weeds, and loss of nitrogen. It aids in reducing the cost of cropping in dryland/

rainfed conditions and ensures a yield advantage when weighed against yield stability under monocropping and fulfilling diversified household needs (Nazir *et al.,* 1997). Cereal-legume mixtures allow us to uphold and perk up soil fertility (Willey, 1979). Under these circumstances, the intercropping with legumes on a long term rotation basis is a good option in arid situations. Though several types of interactions like competition, mutualism, neutralism, commensalism, amensalism, and proto-cooperation may happen when various crops are grown in combinations, yet, yield stability, better utilisation of resources, and limiting weeds, pests, and diseases are merited when crops are grown in associations (Sirkar *et al.,* 2000), in definite row arrangements(Elemo *et al.,* 1990). However, these can be accomplished by making suitable spatial arrangements, plant population and density, varying maturity dates, and plant architecture (Sullivan, 2003)as prevalent in many parts of the world (Andersen *et al.,* 2007; Egbe and Idoko, 2012; Sabaghpour *et al.,* 2005). Among crops, legumes are most preferred due to their ability to acclimatise to different cropping systems and to enhance production capacity as indicated by Kumar *et al.* (2009), and pigeonpea in particular is the best with a mean productivity of 813 kgha-1(Singh, 2007), as intercropping of legumes with oilseeds promotes and ensures resource use efficiency and yield (Singh *et al.,* 2010). But sole pigeonpea is comparatively incompetent because of its sluggish early growth rate and little harvest index (Willey, 1990) and hence it has been grown as an intercrop, which assists in the effective utilisation of available resources for better productivity and profitability.

Four 'Bio' traits of Pigeonpea- a New Insight

The idea of hypothesising 4 'Bio's (bio-ploughing, bio-littering, bio-irrigation, and bio-pumping) of pigeonpea has emanated from authors and has been discussed with literature support hereunder. Sorghum (*Sorghum bicolor* (L.) Moench) is called the camel of crops. Likewise, because of the above mentioned 4'Bio's, pigeonpea is qualified to be called an "anchor crop' in intercropping systems under dryland/rainfed conditions in the tropics. Pigeonpea belongs to the family Leguminosae (Fabaceae). The genus 'Cajanus' belongs to the subtribe 'Cajanae' under the 'Phaseoleae' with the sub-family 'Papilionaceae' (Aiyer, 1950). As per ICBN, the species name adopted is *Cajanus cajan* (L.) Millsp. It has many merits over other short-life legumes, like multiple harvests, soil building capacity, fertility enhancement, and nutrient and moisture contributions. Additionally, drought tolerance capacity is high, coupled with good biomass productivity, which can be primarily used for fodder, and besides, add most to soil (Lose *et al.,* 2003). Pigeonpea offers resilience to rain-dependent intercropping systems often subjected to climate variability and prolonged drought.

Bio-Ploughing

Soil compaction is a relatively common problem in cultivated fields and which adversely affects crop yields. There are many options available to minimise soil compaction problems. Among them, deep ploughing with chisel ploughing, which ploughs up soil to a depth of 45 cm, has been adopted. In addition, an alternative way is to use suitable plant species whose roots, in addition to penetrating compacted soil layers, leave micropores that facilitate the penetration of water and roots of other plants (de Camargo, 1997). Pigeonpea plays an anchor role in particular intercropping situations under semiarid conditions, facilitated by its deep rooting system, which supports the crop in the field and its ability to break hard-dry soil, pushing the crop to be called 'biological plough' by growers. Cintra and Mielniczuk (1983) concluded that an intra-specific variation in capacity to promote soil decompaction exists, that can be utilised as a selection phenomenon for plants. Pigeonpea holds such character (de Camargo 1997), which has been further supported (Alvarenga *et al.,*1996), and pigeonpea roots were unaffected by soil densities above 1.35 Mgm-3. In a highly compacted soil, cultivating soybean after harvest has shown good performance and yields (Silva and Rosolem, 2002). Research on soil decompaction studies using various pigeonpea lines demonstrates their ability to transverse soil layers with increased bulk density, hence, promote soil decompaction.

Bio-Littering

Litter production by pigeonpea and its part in organic matter addition has been very well recognized by several workers. It has a seasonal periodicity and followed a pattern of leaf fall over time. It began from 4th month onwards and a total of 1.9 Mg ha^{-1} of litter (Rao and Gill 1995). However, Sheldrake and Narayanan (1979) observed a litter yield of 2.2 Mg ha^{-1} in a medium duration variety while it was 7.2 Mg ha $^{-1}$ in a long duration variety (Sen, 1958).

Sen (1958) found 100 kg Nitrogen ha^{-1} in a litter, while, Rao and Gill (1995) registered only18 kg N ha^{-1}. But Rao and Gill (1995) from their study observed nitrogen in the litter, stem, and seed was 39.5, 62.6 and 42.7 kg ha $^{-1}$ respectively adding to a total of 144.8 kg ha $^{-1}$ and about 27% of total nitrogen in pigeonpea returned back into the soil.

In pigeon peas, both dry litter and fresh leaf biomass are important sources of easily mineralizable N supply, since their maximum nitrogen (litter fall (1.9%) and green leaf (2.2%) lead to higher decomposition rates. Crop rotation including pigeon peas in of smallholder agriculture has potential for maintaining substantial nitrogen and phosphorus supplies in grains, especially maize, given the lower utilization of external inputs in a maize-based cropping system (Adjei-Nsiah 2012). Adopting a wider spacing helps to add more litter into the soil (Suresh *et al.,* 1991 a&b).

Bio-Irrigation

Lifting water from deeper soil layers to the soil surface is significant for the growth of surface-fed shallow-rooted crops in intercropping under semiarid/rainfed conditions. Deep-rooted plants would restore topsoil layers by the principle of hydraulic lift. It is a process whereby water is transferred from deep moist soil layers into dry topsoil layers through a plant's roots as a result of a soil water potential gradient (Caldwell and Richards, 1989); (Zarebanadkouki *et al.,* 2013); (Carminati *et al.,* 2010). Such deep-rooted plants are capable of performing hydraulic lifts that can be employed as a device for restoring surface soil in cultivated fields, especially in dryland/rainfed situations, and also most likely to facilitate the "bio-irrigation" of adjoining shallow-rooted crops using hydraulically raised water (Dawson, 1993; Burgess, 2011). Thus, bio-irrigation can provide an effective and modest way of improving water relations for shallow-rooted crops during a drought in water-limited areas.

From their experiment on tritium-labelled water raised by alfalfa plants and transported to nearby maize plants, Corak *et al.* (1987) provided the earliest and strongest evidence of bio-irrigation in cropping systems,, and also in maize plants grown near pigeonpea as observed (Sekiya and Yano, 2004). Hirota *et al.* (2004) made a similar statement during an agroforestry trial. When shallow-rooted crops are inter-planted with deep-rooted plants, these studies detail the potential of bio-irrigation to supply water to those crops. The existence of a common mycorrhizal network was also observed to favour the transmission of hydraulic lift water from deep soil layers (pigeonpea) to top surface soil (maize) in a recent study (Singh *et al.,* 2020).

Even though bio-irrigation has positive effects on water-relations and the survival of shallow-rooted crops, when two species are grown side by side in intercropping situations, these two species will compete between them for resources, which affects the growth and yield of individual plants (Rao *et al.,* 1997; Duchene *et al.,* 2017) To ensure bio-irrigation is effective under intercropping, interactions of both complementary and competitive effects between component crops must be studied.

The deep-rooted pigeonpea is generally mixed with shallow-rooted plants in multiple cropping systems to forage on soil water in soil profile layers. Water, being the most critical limiting factor, in semi-arid tropics, ensuring better water use efficiency is the main attribution factor in intercropping. It was observed by Natarajan and Willey (1980) that total water use by both sole pigeonpea and sorghum/pigeonpea intercropping was nearly equal. But it was different in millet/groundnut intercropping where sole crops had higher water use efficiency in a dry season as observed by Reddy and Willey (1981).

Bio-Pumping of Nutrients

Pigeonpea has the potential for recuperating soil fertility and crop productivity by biological nitrogen fixation and thereby restoring soil nitrogen content. Its role in nutrient recycling and food security has been documented. The crop can thrive well under low external input and adverse conditions (Kumar and Paslawar, 2017) because of its deep root system. Perennial pigeonpea produced nearly 25.5 tons of aboveground biomass in 16 months period and high quantities of leaf litter of up to 2 t ha^{-1} in a season might be considered an impending source of nutrients for a succeeding crop (Adjei-Nsiah, 2012). Besides high nitrogen recycling properties, favourable effects on other nutrients may not be ignored as a few studies specified increased phosphorus availability in soil under pigeonpea, which was accredited to solubilisation and also acquisition of phosphorus from bound sources by root exudates named piscidic acid ($C_{11}H_{12}O_7$) which releases P from Fe-P complexes (Ae *et al.,* 1990). The deeper penetrating and sideways spreading root system bestows drought tolerance by ideal utilisation of soil moisture (Sharma, 2009). Moreover, roots present in the deeper soil layers absorb nutrients translocated to deep horizons and recycle it to the top layer (Mason *et al.,* 1986).

All plant parts are generally used for feeding animals and humans, coupled with their role in soil fertility improvement by leaf litter addition and fixation of biological nitrogen (Snapp *et al.,* 2002). It finds a position in any intercropping system because of its poor growth rate and deep root system. During its initial stage, it provides an excellent choice for intercropping with early maturing, fast-growing and shallow-rooted crops (Ramamoorthy *et al.,* 1994). Nevertheless, it is relatively inefficient as an individual crop due to its slow early growth rate (Willey, 1979).

The addition of humus and different rooting patterns of crops ensure efficient utilisation of nutrients, and in intercropping, nitrogen fixation by legumes supports soil fertility maintenance. Ramamurthy *et al.* (2020) reported soil-crop suitability studies that shed light on crop selection, labour and input management, and site-soil suitability evaluation to delineate latent areas of pigeon pea. The deep-rooted pigeon pea also absorbs nutrients from deeper soil layers, thereby recycling nutrients leached from the soil surface. Legumes perform better in a low-phosphorus soil, and the aftermath of one legume affects the subsequent crop.

Intercropping pigeonpea + soybean resulted in higher nitrogen acquisition (Tomar *et al.,* 1997), but it was also higher when intercropped with green gram and cowpea (Singh and Singh, 1992; Reddy *et al.,* 1993) and with soybean (Nimje, 1995). On the contrary, low nitrogen acquisition was reported when intercropped with green gram and cowpea by Patil and Pandey (1996). As regards P acquisition, pigeonpea + green gram increased phosphorus uptake compared to sole pigeonpea (Bishnoi *et al.,* 1987). Nitrogen application at 12.5 kg ha^{-1} and 37.5 kg P_2O_5 ha^{-1} with rhizobium seed inoculation significantly increased phosphorus acquisition and resulted in higher yield (Ramamoorthy *et al.,* 1994). Among different intercrops tried with pigeonpea, pigeonpea intercropping with soybean recorded higher phosphorus acquisition than rest of the intercrops (Verma and Warsi, 1997).

In addition, potassium acquisition was also high when pigeonpea was mixed with green gram (Chandrasekar *et al.,* 1985); blackgram (Kumar, 1993); soybean (Billore *et al.,* 1993) in sandy loam soils. Verma and Warsi (1997) concluded that potassium acquisition was higher under pigeonpea-sorghum intercropping system.

Bio-Advantages

The biological advantages of intercropping systems are measured through various indices and findings and references are indicated in Table (1).

Resources Sharing and Interactions in Legume Intercropping Systems (Table 2)

Growing of two crops together under multiple cropping systems emanates from the fact of varying maturity periods of each species. Both long-duration and short-duration crops are mixed. Intercropping cereals with low-canopy legumes is generally practised in the semi-arid tropics (Singh and Singh, 1980). However, due to spatial differences in leaf crowns and root systems, worthwhile yield advantages could still be possible

Table 1: Bio-advantages of pigeonpea

Land equivalent ratio (LER) Mead and Willey (1980)	
Research evidences	*Reference*
LER helps in measuring mutual association between two crops in using land resources and production output. The highest LER of 1.55 with double row strip of sorghum + two rows of mungbean as intercrop between 90 cm space of sorghum strips	Abdur *et al.,* (2002)
LER is used to calculate efficiency of land under intercropping. LER higher than one ratio is indicative of the fact that intercropping is economical. It was found from the experiment on 30/60 cm paired row planting of capsicum with one row of vegetable cowpea between two pairs of capsicum that LER was higher than unity and it was 1.43 and suggested further that intercropping proved to be beneficial.	Seran and Brintha (2009)
Pigeonpea + sesame and Pigeonpea + blackgram had higher values compared with Bhendi	Subbareddy and Ventateswarau (1992)
Pigeonpea + sesame, pigeonpea + blackgram and pigeonpea + sorghum were best combinations	Singh and Singh (1994)
Pigeonpea + soybean in a 2:4 ratio showed the highest values	Pramila and Kodandaramaiah (1997)
From the studies conducted at the Santa Rosa Experimental Station, belonging to the Universidad Austral de Chile in Valdivia on the efficiency in relative productivity under rainfed conditions of maize cultivars and beans associated and in monoculture revealed that the associations that present comparative advantages in terms LER, ATER, RCC and aggressivity.	(Jana *et al.,* 2000)
Intercropping pigeonpea with finger millet recorded the highest monetary advantage with net returns of Rs. 6967 and Rs. 6660 during first and year of cropping.	(Maitra *et al.,* 2000)
Pigeonpea+sesame had higher LER of more than 1.0	Srinivasulu *et al.,* 2000
Pigeonpea+little millet had higher LER	Ahmad and Prasad (1996)
Area Time Equivalent Ratio (Goyal et al., 1991); (Hiebsch and McCollum 1987)	
It corrects theoretical insufficiency in LER, enables to assess of land use efficiency alongwith time	(Hiebsch and McCollum, 1987)
Compared to sole cropping, pigeonpea+groundnut intercropping showed maximum values for intercropping system indices in Dharwad,Karnataka, India	Hulihalli (1987)
Pigeonpea+sunflower in 2:1 ratio recorded highest yield advantage (40%), maximum ATER values	(Biradar *et al.,* 1988)
Pigeonpea had a ATER (1.09) when intercropped, compared to sole pigeonpea	Pujari and Sheelavantra (1998)
Crop Equivalent Yield (PEY) – (Francis 1986)	
Maximum pigeonpea equivalent yield was recorded from intercropping of pigeonpea and groundnut in various row proportions compared to sole pigeonpea	Ahmed (1991)
Pigeonpea equivalent yield was increased by 33 per cent when pigeonpea was intercropped with soybean or blackgram in 1:1 row proportion over sole pigeonpea	(Dubey *et al.,* 1991)
Pigeonpea+greengram had equivalent yields than sole crops	(Goyal *et al.,* 1991)
An increase of 50% pigeonpea equivalent yield by planting of one row of soybean in between two rows of pigeonpea spaced at 60 cm apart	Prasad and Srivastava (1991)
27% yield increase noticed under intercropping	Singh and Singh (1992)
Pigeonpea+ sunflower intercropping system recorded additional yields	Subbareddy (1992)
Intercropping of pigeonpea + sesame and pigeonpea + groundnut gave higher pigeonpea equivalent yield compared to the sole pigeonpea.	Singh and Singh (1994)
Pigeonpea+ green gram and pigeonpea+soyabean registered a significantly maximum crop equivalent yield.	Pujari and Sheelavantra (1998)
Pigeonpea+bajra had a greater pigeonpea equivalent yield.	Ramulu and Gautam (1999)

(Willey *et al.,* 1982). Intercropping ensures maximum production in a monoculture cropping system (Dahmardeh *et al.,* 2009), because the yield advantage in intercropping is dependent on water, light, and nutrient resources (Jinghui *et al.,* 2006). (Barillot *et al.,* 2014) stated that faba bean-wheat mixture improved resource utilisation by acquiring light, water, and nutrients (Eskandari and Ghanbari, 2010).

Plants in mixed cultures with different canopies can take partial advantage of light as it controls the crop growth, yield components of plants when rest of the crop growth resources are limitless (Natarajan and Willey, 1980). Productivity can be enhanced by maximum solar radiation interception, better light-use efficiency, or a amalgamation of both (Willey, 1990) with ideal crop canopy structure.(Reddy and Willey, 1981) observed that

Table 2: Resource utilisation in intercropping system

Resource	*Remarks*	*Reference*
Light intensity and interception	Instantaneously intercepted to get maximum benefit	Willey (1979)
	Enhanced productivity at higher interception use efficiency	Willey (1990)
	Light interception increase due to soil coverage	Keating and Carberry (1993)
	Intercrops intercept light by 30-40%	Carandang (1980)
Relative humidity, canopy architecture	Cool soil temperatures affect rate of bio-litter breakdown	Wilson and Ludlow (1991)
Water use	water resource capture from a rooting depth doubled in wheat+lucerne	Dunin *et al.,* (1999)
Weed growth	Intercropping prevents weed growth through shade and allelopathy	Asgharipour and Rafiei (2011)
Weed weight	Intercropping affects weed weight	Moatali (2013)
Weed population	Sorghum+cowpea is comparable to pure sorghum	(Saint-John 2009)
Weed population	Pea+basil is comparable to pure pea	(Poggio 2005)

Table 3: Different crops grown as component crop in pigeonpea intercropping systems

Component crop with pigeonpea	*Findings*	*Reference*
Soybean		
Green gram		Raghumurthy (1987)
Blackgram and green gram		(Tewari et al., 1989)
Green gram and cowpea		Patil and Pandey (1996)
Blackgram		(Yadav et al., 1997).
Green gram	Neutral effect	(Sharma et al., 1988)
Sorghum		(Upadhyay et al., 1990)
Green gram	Reduced grain yield	Sing and Singh (1992),
Soybean, green gram, blackgram		(Sarkar et al., 1995)
Green gram, cowpea		Rana and Pal (1997)

millet/groundnut intercrop utilised light much more efficiently than sole crops. Simultaneously growing two or more crops facilitates greater absorption and utilisation of light, water, and nutrients, thereby facilitating better biomass conversion. This is the outcome of disparity in competitive abilities for growth factors between crop components (Anil *et al.,* 1998; Amini *et al.,* 2013). According to Arya and Niranjan (1995), the inclusion of a legume intercropping system has the potential to pull out more moisture from deep soil layers, as a greatest moisture of 10.4 percent was registered under a sorghum + fodder cowpea mixture. Growing crops having different rooting patterns together allows for foraging in different soil layers and exploration for fairly immobile nutrients. As a result, crops grown in intercropped situations absorb extra nutrients than those grown as a sole crop (Horwith, 1985).

Interactions Intercropping Systems

Competition and complementarities are the two most important interactions in intercropping. Willey (1979) sketched out three broad groups of competitive relations in intercropping: 1 mutual inhibition means when the actual yield of each species is less than expected, 2 in mutualism, each species' yield is higher than expected; and 3 the most common situation, where one species yields less than expected and the other more, called compensation. According to him, yield advantage in multiple cropping is certain when component crops differ in the use of growth resources when they can complement each other. Legumes possess greater significance in intercropping systems because of their potential to fix nitrogen and transfer it to associated crops, especially cereals, besides crop geometry and population of component crops (Willey *et al.,* 1980, 1982).

Anchor Crop Effect on Component Crops

Pigeon pea has been grown with other crops in mixed as well as intercropping systems. Pigeon pea acts as an anchor crop and other crops play the role of component crop. Many reports of intercropping with pigeon peas are available and some are listed below (Table 3).

Vice-versa Effects on Anchor Crop

Early maturing crops like green gram and blackgram did not have a deleterious effect on plant height and the number of branches of pigeonpea in intercropped situations (Roy 1981). Intercropping of pigeonpea with green gram did not affect the height growth of pigeonpea (Bishnoi *et al.,* 1987; Tewari *et al.,* 1989) with sorghum (Fujita *et al.,* 1990). Singh *et al.* (1991) stated that pigeonpea recorded a higher number of branches and plant height when intercropped with soybean sown in normal or paired rows. There was no significant reduction in the DMP of pigeonpea when intercropped with sorghum (Singh and

Singh 1994). On the contrary, pigeonpea growth was affected significantly when intercropped with green gram (Kolar *et al.,* 1986; Madhusudan *et al.,*1989), with soybean, green gram, and sesame (Dubey *et al.,* 1991; Pujari and Sheelavantra 1998), with blackgram, soybean, and groundnut (Verma, 2001).

A combination of little millet and pigeonpea at a 2:1 ratio proved to have maximum economic returns and area time equivalent ratio besides recording expressively higher grain yield equivalents(Dubey, 2002). Furthermore, finger millet yields increased by 21%. Pigeonpea equivalent yield (PEY), net returns, and gross returns were higher in the same proportion with higher energy indices in intercropping. (Pradhan *et al.,* 2014) observed that sole finger millet yielded less when grown alone than when intercropped with pigeonpea.

Conclusion

Spatial and temporal variability of rainfall may severely affect the growth and yield of rainfed crops due to intermittent and terminal soil moisture stress, which will ultimately have an impact on the rainfed farmer's economics. Low inputs cause the soils to degrade over time and lose organic matter content. The utility of raising the legumes is more significant in this case. Due to their vital role in rain-fed locations, grain legumes should be chosen. Legumes are rich sources of protein and the most important feature of legumes is biological nitrogen fixation, which acts as a mini nitrogen factory in the intensive farming system, preserving productivity and sustainability. Growing a deeply rooted crop in rainfed areas can at least partially alleviate this dilemma. Pigeonpea's initial sluggish growth rate and deep root system provide ideal opportunity for intercropping in marginal soils with fast-growing, early-maturing, shallow-rooted crops including soybean, green gram, black gram, cowpea, and even small millets (Garud *et al.,* 2020). Pigeonpea typically offers greater consistency and better financial rewards. However, cultivating crops in a mixture with pigeonpea is an excellent way to achieve that in rainfed conditions.

Pigeonpea is a multipurpose legume crop with many uses like food, N fixation, soil improvement agent, soil and moisture conservation properties, fuelwood, and protective cover for soil during dry seasons. Besides, its genetic makeup to withstand moisture stress, and build soil quality even under rainfed or dry conditions qualifies this crop as an anchor crop in intercropping systems under tropical conditions. Hence, inclusion of pigeonpea as an anchor crop in intercropping in the semi-arid tropics ensures the livelihood security of rainfed farmers.

Declaration And Staements

There is no conflict of interest between the authors.

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