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Assessment of Productivity Dyanamics of Chickpea based Intercropping with Linseed and Seed Spices on BBF under Organic Cultivation

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ABSTRACT

Background: The potential of intercropping is well known for multifaceted benefits like greater resource use, reduction of population of harmful biotic agents, higher resource conservation and soil health and agricultural sustainability. These benefits are prominently pronounced in rainfed region. As the legumes crop have much importance in organic farming and there are very close relationships between yield advantage and nutrient acquisition in intercropping systems. By considering this aspect of intercropping system, chickpea intercropped with linseed and seed spices to get higher monetary returns with soil health.

Methods: The field experiment entitled "assessment of productivity dyanamics of chickpea based intercropping with linseed and seed spices on bbf under organic cultivation'' was conducted during *Rabi* season of 2019-20 to 2022-23 at certified organic research farm of Centre of Organic Agriculture Research and Training (COART), Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra).

Result: In case of chickpea, the crop growth parameters and yield attributes of chickpea were found to be improved with sole cropping of chickpea than intercropping system with linseed and seed spices. However, in case of other crops, higher crop growth parameters and yield attributes of ajwain were found in intercropping system with chickpea.

Key words: Ajwain, BBF, Chickpea, Intercropping, Linseed, Organic cultivation.

INTRODUCTION

Due to intensive cultivation after green revolution use of high doses of chemical fertilizers and insufficient use of organics *i.e.* farm yard manure, compost, crop residue, green manure, biofertilizers *etc*. fertility of the soil has been degraded. Continuous use of inorganic fertilizers has not only brought loss of vital flora and fauna but also resulted in loss of micro-nutrients. Organic farming emerged as a potential alternative for meeting food demand, maintaining soil fertility and increasing soil carbon pool. However, Indian organic farming industry is almost entirely export oriented. Increasing awareness about conservation of environment as well as health hazards associated with agrochemicals and consumer preference to safe and hazards free food are the major factors that lead the growing interest in organic agriculture in the world. Organic agriculture without doubt is one of the fastest growing sectors of agricultural production (Paslawar *et al.*, 2023).

Intercropping is an important aspect than sole cropping to growth of more than one crop species or cultivars simultaneously in the same field during a growing season. It is practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms. There are very close relationships between yield advantage and nutrient acquisition in intercropping systems. It is an efficient cropping system in terms of resource utilization. It is mainly related to complementary use of environmental resources by the component crops which result in increased and more stable yields. Especially the information on promising intercropping system under delayed monsoon conditions has been lacking which is required for contingency planning. Success of intercropping in comparison with a pure cropping can be determined by a series of agronomic operations that interactions between the species will be affected by them. These operations are including ultimate density, planting date, resources availability and intercropping models (Mazaheri *et al.*, 2006 and Gliessman, 1997). If there are "complementary effects" between the components of intercropping, production increases due to reducing the competition between them (Mahapatra, 2011; Zhang and Li, 2003 and Willey, 1979). Willey (1990) considers intercropping as an economical method for

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higher production with lower levels of external inputs. This increasing use efficiency is important, especially for small-scale farmers and also in areas where growing season is short. Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases and weeds (Udhaya Nandhini and Somasundaram, 2020). Intercropping is a system that focuses on the better exploitation of sunlight, effective utilization of nutrients and water, risk reduction and higher exploration of the growth factors from the environment (Mobasser *et al*., 2014; Ajibola and Kolawole, 2019). On the other hand, oilseed and spices are important ecologically hardy crops of rainfed area which can provide food and nutritional security to smallholders. On the basis of available literature studied it can be said that intercropping of pulses with oilseed and seed spices in rainfed area is one of the suitable options to harness ecologically sound agriculture. There is enough scope for future research which can further boost economy of smallholders with agricultural sustainability in rainfed area (Maitra, 2020). Organic farming with intercropping has potential to increase net returns, reduce the risk of crop failure and reduce environmental impacts. Hence, promising chickpea based intercropping system was tested for their response with spices and linseed to evaluate their yield potentiality and system profitability.

MATERIALS AND METHODS

The presented experiment conducted during the *rabi* season of 2019-2020 to 2022-23 at Centre for Organic Agriculture Research and Training, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The certified organic farm is located in the subtropical region at North latitude 220 42′ and East latitude 770 02′. This farm lies at an altitude of 307.42 m above mean sea level and near the Tropic of Cancer and becomes very hot during the march to May. The average annual precipitation is 811.9 mm (30 year). The normal mean monthly maximum temperature is 42.2°C mostly hottest during may month, while normal minimum temperature is 10.6°C in the coolest December month. The soil of experimental plot was clayey in texture. Soil was slightly alkaline in nature. The chemical composition of soil stated that medium in organic carbon, low in available nitrogen, very low in available phosphorus and high in available potassium. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and three replications. The treatments with 2:1 ratio in intercropping system were T1- Sole Chickpea, T2- Sole Linseed, T3- Sole Coriander, T4- Sole Ajwain, T5- Chickpea + Linseed (2:1), T6- Chickpea + Coriander (2:1), T7-Chickpea + Ajwain (2:1). The varieties adopted were JAKI-9218 (Chickpea), NL-260 (Linseed), ACR-1 (Coriander) and AA-19-01 (Ajwain). The other cultural practices were kept common, as recommended.

The consequent observation on growth, yield and quality parameters recorded treatment wise. The growth attributes such as plant height measured manually by using meter scale, number of branches measured manually by simple counting and dry matter plant^{-1} (g) measured manually by weighing the dry weight of plant. The observations on yield and yield attributes were recorded after the harvest of crops. Plants from the net plot area of each crop were harvested separately according to their harvesting dates leaving border rows after collecting the five tagged observation plants. Chickpea (101 days), Coriander (98 days), Linseed (108 days) and Ajwain (125 days) were harvested by manual labor through completely slashing the shoot while leaving the root biomass in the field. The threshing of chickpea, coriander, linseed and ajwain was carried out manually by labor and the straw spread over the field for in-situ decomposition. The seeds and straw of Chickpea, Coriander, Linseed and Ajwain were cleaned, dried and weighed. Fig 1, Fig 2 and Fig 3 presented the crop condition after 45 days of sowing. The growth and yield parameter *viz*. plant height (cm), number of branches, dry matter plant^{-1} (g), seed yield plant^{-1} (g), seed yield (kg ha^{-1}), stalk yield (kg ha^{-1}) and biological yield (kg ha^{-1}) has been interpreted on general mean basis. Harvest index (HI) refers the yield of plant parts of economic interest as a percentage of total biological yields in terms of dry matter. The harvest index was calculated from each net plot by using the formula as suggested by Donald (1962):

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

As the crops are different and for the statistical analysis same crop are required so we take the data on mean basis. Similarly the analysis done by Paul *et al.* (2015); Gupta *et al.* (2019). However, the randomized block design has been applied to the economics, CEY and LER.

The total value of produce *i.e.*, seed and straw yield was calculated treatment wise as per the prevailing MSP and GMR was calculated. The total cost of cultivation was calculated considering the inputs used in each treatment with prevailing market rates. The total cost of cultivation was negated by the GMR to obtain NMR. The benefit- cost ratio was calculated by dividing the GMR with the total cost of cultivation. The yields of the intercrops are appropriated to the chickpea equivalent yield (kg ha^{-1}) by using the formula which was given by Lal and Ray (1976).

$$\text{CEY} = \frac{\text{Intercrop yield} \times \text{Price of intercrop}}{\text{Price of chickpea}} + \text{Chickpea yield}$$

Land equivalent ratio (LER) is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping (Brintha and Seran, 2009). The LER is a standardized index that is defined as the relative area required by sole crops to produce the same yield as intercrops (Mead and Willey, 1980). LER compares yields from growing two or more crops together with yields from growing the same crop in monocultures or pure stands. LER was calculated as,

$$LER = \frac{Yij}{Yii} + \frac{Yji}{Yjj}$$

Where,

Yii and Yjj = Denote yield of crops i and j in sole cropping.

Yij and Yji = Corresponding yield in intercropping.

An LER of 1.0 indicates that intercropping and sole cropping have yield equivalent. LER >1.0 indicates that intercropping has yield advance over sole cropping while an LER<1.0 indicates a disadvantage of intercropping. The statistical method of analysis of variance was used for analyzing the data. The data were statistically analyzed by 'Analysis of Variance' method (Panse and Sukhatme, 1967) and 'F' test of significance was used for testing the 'null hypothesis' in order to determine whether the observed treatment effects were real and discernible from chance effects. Whenever the results were found to be significant, critical difference (C.D.) was calculated for the comparison of treatment means at 5 per cent levels of significance (P = 0.05). The results have been presented in the form of summary table providing S.E. (m) in each case and C.D. at 5 per cent level. The values of C.D. have been taken into account for drawing conclusions.

RESULTS AND DISCUSSION

The pooled data of five year of experiment (2019-20 to 2022-23) pertaining to growth attributes presented in Table 1 showed that various growth attributes of chickpea, linseed and seed spices was influenced by different intercropping system at harvest stage. In case of chickpea, maximum growth attributes such as plant height (cm), number of branches and dry matter plant^{-1} (g) were observed highest in sole chickpea cropping system than other chickpea based cropping system. In case of other crops, at the time of harvesting stage, sole cropping of linseed, coriander and ajwain attained maximum growth attributes such as plant height (cm), number of branches and dry matter plant^{-1} (g) as compare to intercropped with chickpea in 2:1 row proportion. The increased in growth attributes such as plant height (cm), number of branches and dry matter plant^{-1} (g) of chickpea, linseed and other seed spices in sole cropping, might be primarily due to decreased competition between plants for sunlight and nutrients which compelled the plants to grow more vertically rather than horizontally. The shorter plants of chickpea, linseed and other spices were found when intercropped 2:1 row ratios as in intercropping system the crops faced competition for sunlight and nutrients. The seed yield plant^{-1} differed due to chickpea based intercropping. Seed yield plant^{-1} was recorded in sole chickpea (13.60 g). Maximum seed yield recorded in chickpea intercrop with ajwain (14.74 g plant^{-1}) followed by chickpea + coriander (2:1) recorded (12.57 g plant^{-1}). While in case of chickpea intercrop with linseed, lowest seed yield plant^{-1} of chickpea (10.73 g) was recorded. This was due to interspaces and cooperative interaction of intercrops with chickpea for non-renewable resources like water, nutrients and light. These results corroborated with the finding of Kour *et al*. (2014) and Kumar *et al*. (2018). It has been observed that Rhizobium culture and phosphorus solubilizing bacteria (PSB) both given beneficial effect on plant height of chickpea reported by Kumar *et al*. (2014). Dwivedi *et al*. (2014) reported that a significant increase in plant height was recorded with the application of jivamrut besides positive impacts on physico-chemical properties of soil. In contrary to this, linseed, coriander and ajwain recorded more dry matter production in intercropping system with chickpea over their sole cropping, might be due beneficial effect of legume based intercropping. Similar findings reported in Alam (2017). Application of vermicompost increased availability of nutrients in the root

Fig 1: Chickpea + Linseed (2:1).

Fig 2: Chickpea + Coriander (2:1).

Fig 3: Chickpea + Ajwain (2:1).

zone with higher metabolic activity at the cellular level might have enhanced the nutrient uptake and accumulation in the vegetative parts, which in turn resulted in higher dry mater content in ajwain. Similar findings reported by (Thanuja *et al*., 2020).

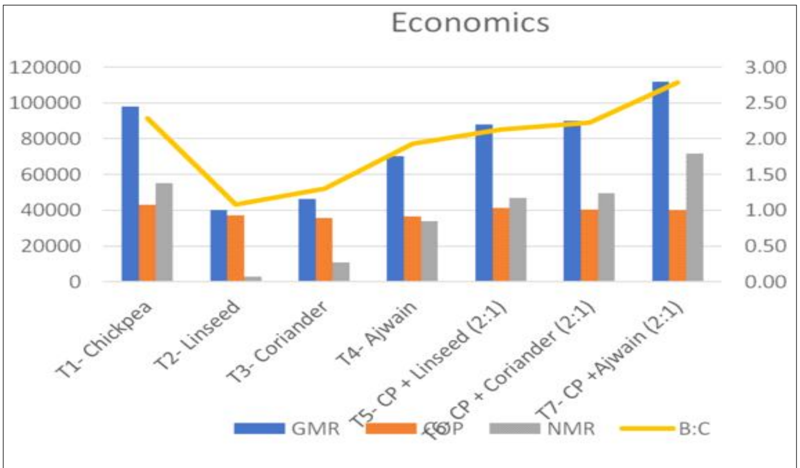
The pooled data of five year of experiment (2019-20 to 2022-23) pertaining to yield presented in Table 2 showed that the higher seed yield of chickpea was recorded in sole cropping (1633 kg ha^{-1}). However, in case of different intercropping systems chickpea + ajwain recorded more yield of chickpea (1323 kg ha^{-1}) than chickpea + coriander (1213 kg ha^{-1}) and chickpea + linseed (1149 kg ha^{-1}). In case of linseed and seed spices higher seed yield recorded in sole cropping than their intercropping due to maximum plant population in sole cropping on unit area basis. This might be due to direct interaction between number of root nodules and higher N fixation and application of organics sources of vermicompost 2 t ha^{-1} noticed higher number of total root nodules and effective root nodules which resulted in manifestation of higher growth and yield attributing characters and higher yield of chickpea. These results are in agreement with finding of Singh and Prasad (2008). While, numerically higher stalk yield of chickpea was recorded in sole cropping (2786 kg ha^{-1}). However, in case of different intercropping systems, chickpea + ajwain (2:1) recorded more yield (2107 kg ha^{-1}) than chickpea + coriander in 2:1 ratio (2012 kg ha^{-1}) and chickpea + linseed in 2:1 ratio (1713 kg ha^{-1}). While in case of sole linseed stalk yield (2284 kg ha^{-1}) was recorded followed by sole ajwain (1939 kg ha^{-1}) and sole coriander (1498 kg ha^{-1}) however in linseed when intercrop with chickpea recorded (1054 kg ha^{-1}) chickpea + ajwain 2:1 (886 kg ha^{-1}) and chickpea + coriander (637 kg ha^{-1}). Similar result reported by Upadhyay *et al*. (2019). The greater biological yield of chickpea was recorded in sole cropping (4419 kg ha^{-1}). While in case of intercrop with ajwain obtained (3430 kg ha^{-1}), coriander recorded (3225 kg ha^{-1}) and linseed recorded (2862 kg ha^{-1}). However, in sole linseed, sole coriander and sole ajwain recorded higher biological yield that was 3012, 2211 and 2660 kg ha^{-1} than their biological yield of intercropping with chickpea. The data recorded for harvest index showed variation due to intercropping of chickpea with linseed and seed spices. Numerically higher harvest index of chickpea recorded in chickpea + linseed (40.15%) and chickpea + ajwain (38.57%) followed by chickpea + coriander (37.61%). However, lowest harvest index found in sole chickpea (36.95%). While in concern with linseed and seed spices inter cropping favours more harvest index as compared to sole cropping system.

The pooled data of five year of experiment (2019-20 to 2022-23) pertaining to economics presented in Fig 4 showed that the different cropping system varied markedly in benefit obtained from each treatment. Significantly highest B:C ratio was recorded with chickpea + ajwain (2:1) intercropping system which was about 2.79 and lowest B:C ratio was recorded with sole linseed (1.08). Higher B:C ratio obtained

Table 1: Pooled plant height (cm), number of branches, dry matter plant^{-1} (g) and seed yield plant^{-1} (g) of *kharif* intercrops (2018-19 to 2022-23).

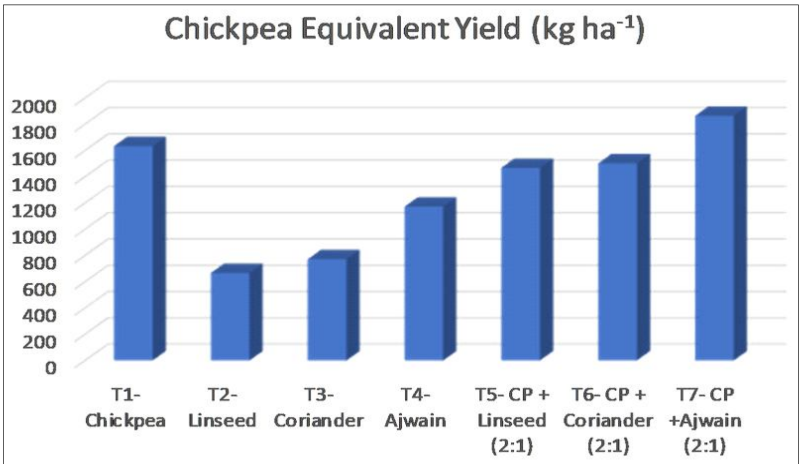
Rabi intercrop	Plant height (cm)				Number of branches				Dry matter plant^{-1} (g)				Seed yield plant^{-1} (g)			
	Main crop	Intercrops			Main crop	Intercrops			Main crop	Intercrops			Main crop	Intercrops		
	CP	LN	CD	AJ	CP	LN	CD	AJ	CP	LN	CD	AJ	CP	LN	CD	AJ
Chickpea	42.8	-	-	-	4.2	-	-	-	23.92	-	-	-	13.60	-	-	-
Linseed	-	55.2	-	-	-	3.5	-	-	-	6.4	-	-	-	4.72	-	-
Coriander	-	-	54.2	-	-	-	3.9	-	-	-	6.8	-	-	-	3.43	-
Ajwain	-	-	-	90.8	-	-	-	8.6	-	-	-	12.43	-	-	-	2.34
Chickpea + Linseed (2:1)	40.5	51.6		-	3.3	4.2	-	-	20.74	7.2	-	-	10.73	5.17	-	-
Chickpea + Coriander (2:1)	41.1	-	52.4	-	3.5	-	4.1	-	17.66	-	7.2	-	12.57	-	3.91	-
Chickpea + Ajwain (2:1)	41.3	-	-	88.2	3.7	-	-	9.4	22.54		-	13.82	14.74	-	-	2.57
GM	41.4	53.4	53.3	89.5	3.6	3.8	4.0	9.0	21.21	6.8	7.0	13.12	12.91	4.94	3.67	2.45

Note: CP- Chickpea, LN- Linseed, CD- Coriander, AJ- Ajwain.



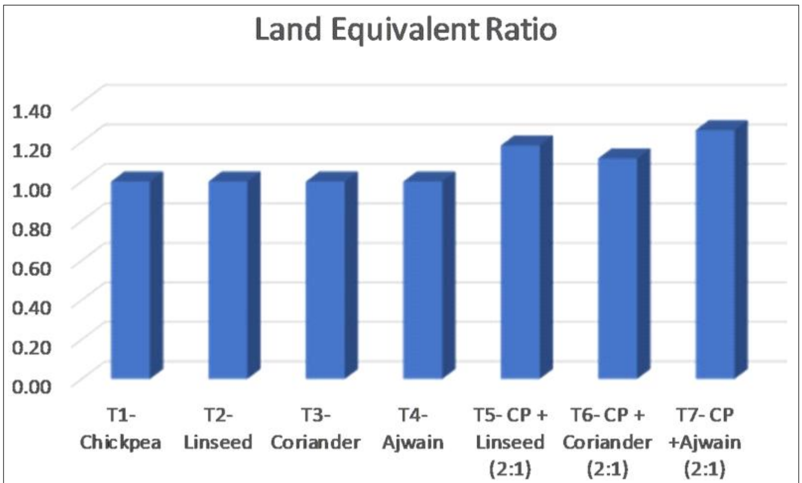
Note: CP- Chickpea, LN- Linseed, CO- Coriander and AJ- Ajwain.

Fig 4: Pooled economics of chickpea and other crops as influenced by intercropping systems.



Note: CP- Chickpea, LN- Linseed, CO- Coriander and AJ- Ajwain.

Fig 5: Chickpea equivalent yield (CEY) of chickpea and other crops as influenced by intercropping systems.



Note: CP- Chickpea, LN- Linseed, CO- Coriander and AJ- Ajwain.

Fig 6: Land equivalent ratio (LER) of chickpea and other crops as influenced by intercropping systems.

Table 2: Seed yield, stalk yield, biological yield and harvest index of chickpea, linseed and seed spices as influenced by intercropping systems.

Treatments	Seed yield (kg ha^{-1})				Stalk yield (kg ha^{-1})				Biological yield (kg ha^{-1})				Harvest index (%)			
Intercropping systems	Main crop	Intercrops			Main crop	Intercrops			Main crop	Intercrops			Main crop	Intercrops		
	CP	LN	CO	AJ	CP	LN	CO	AJ	CP	LN	CO	AJ	CP	LN	CO	AJ
T1 - CP sole	1633				2786				4419				36.95			
T2 - LN sole		728				2284				3012				24.17		
T3 - CO sole			713				1498				2211				32.25	
T4 - AJ sole				721				1939				2660				27.11
T5 - CP + LN	1149	348			1713	1054			2862	1402			40.15	24.82		
T6 - CP + CO	1213		266		2012		637		3225		903		37.61		29.46	
T7 - CP + AJ	1323			324	2107			886	3430			1210	38.57			26.78
GM	1330	538	490	523	2155	1669	1068	1413	3484	2207	1557	1935	38.32	24.50	30.85	26.94

Note: CP- Chickpea, LN- Linseed, CD- Coriander, AJ- Ajwain.

in chickpea + ajwain (2:1) intercropping combination due to better performance of component crops which gives higher productivity and net return. Similar results also earlier reported by Gupta *et al*. (2019) and Tanwar *et al*. (2011). The presented data in Fig 5 revealed that, chickpea equivalent yield recorded maximum in chickpea + ajwain (2:1 ratio) intercropping (1864 kg ha^{-1}) among rest of the sole and intercropping treatments. While chickpea + coriander (2:1) recorded (1502 kg ha^{-1}) at par with chickpea + ajwain (2:1) intercropping system. However, chickpea equivalent yield of other intercropping system recorded was 1633 kg ha^{-1} in sole chickpea, 1468 kg ha^{-1} in chickpea + linseed, 772 kg ha^{-1} in sole coriander, 1172 kg ha^{-1} in sole ajwain and 667 kg ha^{-1} in sole linseed which was lowest among all cropping system. Chickpea + ajwain (2:1) intercropping system recorded maximum chickpea equivalent yield among all intercropping system it was due to higher intercrop yield compared to sole. Higher chickpea and ajwain yield due to better complimentary relationship and higher market price. Similar results were also reported by Ghatal *et al*. (1997). As compared to sole cropping chickpea equivalent yield of intercropping was recorded maximum. Similar results were reported by Shukla *et al*. (2020) and Gupta *et al*. (2019). The data pertains to Fig 6 revealed that maximum value of land equivalent ratio was recorded in chickpea + ajwain (2:1) intercropping by achieving LER of 1.26. However, in chickpea + coriander (2:1) recorded 1.19 and in chickpea + linseed (2:1) 1.18 LER. Higher land equivalent ratio of intercropping system obtained might be due to higher yield of chickpea and ajwain and also due to more land utilization in intercropping system over its sole cropping system. Dwivedi *et al*. (2015) reported that the most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available resources using a mixture of crops of different rooting ability, canopy structure and height and nutrient requirements based on the complementary utilization of growth resources by the component crops. Wasu *et al*. (2013) and Gupta *et al*. (2019) reported similar results.

CONCLUSION

From the present study, it is inferred that the sole cropping of chickpea recorded maximum values of growth parameters, however, in case of linseed and seed spices; these parameters were maximum in intercropping system of chickpea with ajwain (2:1). The yield and yield parameters were highest in chickpea + ajwain (2:1) intercropping system. Also, chickpea + ajwain (2:1) intercropping found as the most efficient cropping system by recording significantly higher chickpea equivalent yield, land equivalent ratio, gross monetary returns, net monetary returns and B:C ratio. Thus, the pulses based intercropping system could be used to construct a biologically diverse agricultural system that can replenished and maintained soil fertility, while also promoting a healthy environment for better crop growth.

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Conflict of interest

All authors declared that there is no conflict of interest.

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