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Chickpea Thrive: Unleashing Potential in Intercropping Systems with Different Organic and Natural Farming Practices

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ABSTRACT

Background: The chemical use is hitting the sustainability in soil and decreasing its potency. The imbalanced and continuous use of chemical fertilizers in intensive cropping system has led to reduction in the crop yields and resulted in imbalance of nutrients in soil which has adverse effect on soil physico-chemical properties. Organic and natural farming presents a valid alternative approach to conventional farming due to its potential to contribute quite substantially to the global food supply, while reducing the detrimental environmental impacts of conventional agriculture. Hence, the current experiment aimed to evaluate chickpea based intercropping system for their response with seed spices, linseed and sorghum to evaluate their growth, yield attributes and yield.

Methods: This study was conducted during the *rabi* season of 2022-2023 and 2023-2024 in at Centre for Organic Agriculture Research and Training, Department of Agronomy and analytical work was conducted at Center for Organic Agriculture Research and Training laboratory, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Result: Results revealed that among various intercropping systems, significantly taller plants along with higher LAI, dry matter accumulation, yield attributes and yield were observed under sole chickpea and in organic nutrient modules highest growth parameters, yield attributes and yield were recorded with integration of both organic and natural farming practices.

Key words: Biofertilizers, Intercropping, Natural farming, Organic farming, Sustainability.

INTRODUCTION

Organic agriculture is a production system that sustains the health of soil, ecosystem and people. It relies on ecological processes biodiversity and cycles adapted to local conditions rather than the use of input with adverse effects. Unlike chemical farming, organic farming aims to "feeding the soil" rather than "feeding the plant". It is the means of giving back to nature what has been taken from it. Since organic farming aims at maintaining soil health the optimum yield can be obtained in a sustainable and eco-friendly manner in the long run. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people (Scialabb and Hattam, 2002). The healthy soil in organic farm resulted in considerably lower insect and disease incidence. After the green revolution fertility of the soil has been degraded due to intensive cultivation, use of high doses of chemical fertilizers and insufficient use of organics *i.e.* farmyard manure, compost, crop residue, green manure, bio-fertilizers, *etc*. At present time we face many challenges to achieve sustainable food security and quality of food materials. In a world battered by the COVID pandemic, the demand for healthy and safe food is already showing an upward trend and hence this is an opportune moment to be captured for a win-win situation for our farmers, consumers and the environment.

According to survey India holds a unique position among 187 countries practicing organic agriculture. India is home to 30% of total organic producers in the world having 2.30 million ha. Total organic cultivation area, 27, 59,660 total farmers (11, 60,650 PGS and 15, 99,010 India organic), 1703 total processors and 745 traders. A major relative increase of organic agricultural land was noted in recent past throughout the country (FiBL, 2021) Organic farming is in a nascent stage in India. About 2.30 million hectares of farmland was under organic cultivation as of March 2019. This is two per cent of the 140.1 million ha net sown area in the country (Surpura *et al.,* 2025). A few states have taken the lead in improving organic farming coverage, as a major part of this area is concentrated only in a handful of states. Madhya Pradesh tops the list with 0.76 million ha of area under organic cultivation-that is over 27 per cent of India's total organic cultivation area. The top three states-Madhya Pradesh, Rajasthan and Maharashtra-account for about half the area under organic cultivation (Anonymous, 2018).

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Natural farming (NF) is considered to be agroecology based diversified farming system, which integrates crops, trees and livestock, allowing functional biodiversity (Rosset and Martinez, 2012) to drastically cut down production costs by replacing the chemical fertilizers and pesticides with home-grown product like *Jeevamrith, Beejamrith, Neemastra etc*. and adopting intercropping and mulching (Palekar, 2005; 2006; Swami, 2006). Highlighting the predominance of smallholder farmers (68.5 per cent marginal and 17.7 per cent small farmers) in India. The Economic Survey (2019) emphasized the importance of Zero Budget Natural Farming (ZBNF) as one of the alternative farming practices for improving the farmers' income, in the backdrop of declining fertilizer response and farm income. Biological sciences (*e.g.* microbiology, ecology, soil science) with their increasingly "symbiotic" (Gilbert *et al*., 2012) and "probiotic" (Lorimer, 2017) understandings of soil and plant life are also an inspiration for the ecological renewal of agriculture. The core idea of natural farming is to encourage the growth of beneficial microbes without relying on external fertilizers or synthetic pesticides. Legumes, in this context, are valuable because they capture atmospheric nitrogen, enriching the soil (Raveena *et al*., 2024).

Initially, a Japanese farmer, Masanobu Fukuoka proposed natural farming, which is based on the philosophy of working with natural cycles and processes of the natural world (Fukuoka, 1987). The movement of promoting ZBNF in India has been championed by Shri Subhash Palekar has resulted into widespread adoption at varying levels in many states, especially andhra Pradesh, Karnataka, Maharashtra, Himachal Pradesh) (Khadse *et al*., 2017; Mishra, 2018; Niyogi, 2018). However, in recent times, a section of scientific community and critics vehemently oppose this alternative practices condemning it being not based on scientific evidences, promoting certain beliefs system, particularly indigenous cows, a backward-looking and chauvinistic idiom (Shotwell, 2016; Saldanha, 2018). After having exhaustive study of the movement, Munster (2018) believes that the prevalent ambivalence makes natural farming a valuable case for the political ecology of agriculture. Moreover, most of these studies lack field level or experimental evidences to support their arguments. With this ambiguous context, the present study is an attempt to understand the practices followed by the farmers under natural farming; examine the adoption of practices by the farmers and to study the implication on costs of crop cultivation, yield and farmers income for major crops in the study area.

In 2006, the National Centre for Organic Farming (NCOF) and National Horticulture Mission (NHM) incorporated cow-based bio-enhancers into practices for organic cultivation of different crops. Modules on organic farming also include bio-enhancers. A bio-enhancer is a product derived from fermentations of plant and animal residues over a specified period of time (Chaudhary *et al.,* 2025). The plant growth promoting substances, such as immunity enhancers, are abundant in these sources because they contain microbial consortia, macro and micronutrients. This is generally used to treat seeds/seedlings, promote decomposition of organic material and increase plant vigour (Pathak and Ram, 2013).

Natural farming is a multifaceted approach that encompasses a diverse range of inputs, each play distinct roles as growth promoters, protectors against pests and diseases and contributors to overall soil health. Central to various microbial activities associated with these inputs, which exert both direct and indirect influences on plant growth and protection. Natural farming practices are interconnected and contribute to various mechanisms that improve soil health, nutrient availability and water efficiency, leading to a more resilient agricultural system and potentially higher crop yields with better carbon accumulation in the soil (Mishra *et al*., 2023). The total volume of export during 2020-21 was 888179.68 MT. The organic food export realization was around INR 707849.52 lakhs (1040.95 million USD). Organic products are exported to USA, European Union, Canada, Great Britain, Korea Republic, Israel, Switzerland, Ecuador, Vietnam, Australia *etc*. In terms of export value realization processed foods include soyameal (57%) lead among the products followed by oilseeds (9%), cereals and millets (7%), plantation crop products such as Tea and Coffee (6%). Spices and condiments (5%), Dry fruits (3%), sugar (3%) and others (https://www.ibef.org/indianrice/organic-products).

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 (Paslawar *et al*., 2024). 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. Organic farming and natural farming along 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 coriander, linseed and sorghum to evaluate their yield potentiality and system profitability. 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; 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; Willey, 1979). Willey (1990) considers intercropping as an economical method for 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.

Chickpea *(Cicer arientinum)* the most important pulse crop of *rabi* season, is cultivated mainly in semi-arid and warm temperature regions of the world. Chickpea is known by its different names like Bengal gram in English and *Chana* in Hindi. It is probably the highest protein containing grain legume except groundnut and soybean. The high nutritional value makes chickpea an important food particularly in famine prone areas of the world.

Globally, Bengal gram is cultivated on 15 million hectares, producing over 18.1 million tonnes during 2022-23. India is a largest producer of chickpea in the world with 13.75 million tonnes from an acreage of 10.91 million hectares, with a productivity of 10.12 quintals per hectare. (Statista, 2022-23). Though India is a largest producer, but it stands at 8th position in productivity with 1012 kg per hectare. Ethiopia has highest productivity of 2072 kg per hectare followed by USA with 1822 kg per hectare. The chickpea market is expected to grow to $19.19 billion by 2027 at a CAGR of 6.5%. Chickpeas contribute nearly 50% of India's pulse production. The major producing states are Maharashtra (2.631 million hectares), Madhya Pradesh (2.346 million hectares), Rajasthan (1.938 million hectares), Uttar Pradesh (0.682 million hectares), Karnataka (0.962 million hectares) and Gujarat (0.631 million hectares). Chickpea contains 21% protein, 61% carbohydrate and 2.2% oil (Gupta, 1988). It contains high quality protein and is suited for animal feed as well as for human diet. Due to its deep root system, it can withstand extended periods of drought by extracting water from deeper layer of soil. It is used in crop rotation (Sachin and Gecit, 2006) and has atmospheric nitrogen fixation ability (Jain *et al.,* 1993) and other most important thing about the intercrop is that it plays the crucial role in organic farming system (Mohammadi *et al.*, 2010). In rainfed areas where probability of crop failure is higher due to frequent occurrence of weather aberrations, intercropping can be more stable and dependable than sole cropping (Rao and Willey, 1980). So intercropping of chickpea with linseed and seed spices under organic condition can be better option in this area.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2022-23 and 2023-24 at Centre for Organic Agriculture Research and Training field, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to study the effect of different organic modules on yield and yield attributes of chickpea based intercropping systems. The soil of the experimental site was medium, black in colour with good drainage. The experiment was laid out in Strip plot Design. The main treatments were Chickpea (sole), Chickpea + Coriander (2:2), Chickpea + Linseed (2:2) and Chickpea + Sorghum (2:2), sub plot treatments includes N1: Organic farming - (Biofertilizers + Vermicompost + Biopesticide, N2: Natural farming - (*Ghanajeevamrith* + *Beejamrith* + *Jeevamrith* + Neemastra) and N3: Integration of Organic farming and Natural farming - (Biofertiizer + Vermicompost + *Jeevamrith* + Neemastra) replicated four times. All the crop details were mentioned in the Table 1.

Sowing was done by dibbling on 13th Nov 2022 and 11th November 2023 and harvesting was done by 6th Mar 2023 and 01 mar 2024. Initially soil organic carbon was recorded to be 4.6 g kg^{-1}. The observations on plant height, leaf area index and dry matter accumulation were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing characters were recorded as per the standard method. Yield attributes were also recorded at physiological maturity stage. The seed and stover yield was recorded from net plot area of each treatment and was equated to one hectare area. The data obtained from various characters under study were analyzed by the method of analysis of variance as described by (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters like plant height, leaf area index and dry matter accumulation were significantly varied among different intercropping systems and organic nutrient modules.

The data of plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}) as influenced by various treatments are presented in Table 2. The apical meristem, plays a vital role in this process by continuously dividing and elongating, thus contributing to the primary plant body. Intercropping systems, which involve growing two or more crops together in proximity, can have diverse effects on plant growth. Factors such as competition for resources

Table 1: Crop details.

Crop	Variety	Spacing (cm)	Seed rate (kg/ha)
Chickpea (*Cicer arietinum*)	JAKI-9218	45 × 10	75
Coriander (*Coriandrum sativum*)	ACR-1	45 × 05	12
Linseed (*Linum usitatissimum*)	NL-260	45 × 05	15
Sorghum (*Sorghum bicolor*)	PKV Kranthi	45 × 20	10

like water, nutrients and light, as well as allelopathic interactions, can influence the growth patterns of the crops involved. Observing plant height throughout the growth stages allows researchers and farmers to assess how these factors impact the plants.

Intercropping system

The effect of different chickpea based cropping system on plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}) were recorded at harvest. Among all the chickpea based cropping systems, higher plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}) were recorded with sole chickpea (46.51, 0.65 and 20.95) respectively, which was on par with chickpea + coriander (2:2) intercropping system (46.14, 0.63 and 20.55) respectively at all growth stages which could be attributed to the synergistic complimentary effect of legume and the crowding effect of the intercropping system. Plant height increased in case of sole cropping might be primarily due to less competition between plants for sunlight and nutrients which enforced the plants to grow more vertically as there was no interspecies interaction plants can able to grow freely. 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 growth parameters of chickpea reported by Kumar *et al.* (2014). Dwivedi *et al.* (2014) reported that a significant effect on growth parameters were recorded with the application of *Jeevamrith* besides positive impacts on physico-chemical properties of soil.

Nutrient management practices

During the study integration of organic and natural farming exhibits maximum values for plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}) (45.75, 0.64, 20.10) respectively, which was significantly superior over sole organic and sole natural farming. It might be due to enhancement of availability of nutrients (major and micro nutrients) to plants resulted in profuse shoot and root growth and thereby activating greater absorption of nutrients from soil.

Interaction

The interaction effect due to different chickpea based cropping systems and nutrient organic modules with respect to growth parameters were found to be not significant.

Yield attributes and yield

All yield contributing characters of chickpea *i.e.* number of pods plant^{-1}, weight of pods plant^{-1} (g) and seed index (g) differed due to different cropping systems and organic nutrient modules and the data presented in Table 2.

Seed yield (kg ha^{-1})

The data pertaining to yield of different crops as influenced by various intercropping systems and different organic nutrient modules of both the years were tabulated in the Table 3. The maximum seed yield of chickpea was observed in sole chickpea (1866, 1797 and 1831 kg ha^{-1}) during 2022-23, 2023-24 and pooled respectively. In the intercropping system, highest yield of chickpea was observed when intercropped with the coriander 908, 873 and 890 kg ha^{-1} during 2022-23, 2023-24 and pooled respectively. Where as seed yield of chickpea among different organic nutrient modules was recorded highest with integration of both natural and organic farming 1149, 1072 and 1111 kg ha^{-1} during 2022-23, 2023-24 and pooled respectively. The mean yield of various inter crops such as coriander, linseed and sorghum were recorded to be in

Table 2: Growth parameters and yield attributes of chickpea as influenced by intercropping systems and nutrient management (pooled data of 2022-23 and 2023-24).

Treatment	Plant height (cm)	LAI	DMA (g plant^{-1})	No. of pods plant^{-1}	Weight of pods plant^{-1} (g)	Seed index (g)
Cropping systems						
C_1: Chickpea (sole)	46.51	0.65	20.95	31.51	14.35	22.33
C_2: Chickpea + coriander (2:2)	46.14	0.63	20.55	30.99	13.99	21.47
C_3: Chickpea + linseed (2:2)	43.97	0.57	18.17	29.27	12.39	21.17
C_4: Chickpea + sorghum (2:2)	40.81	0.51	15.95	27.22	11.36	21.00
SEm±	0.26	0.01	0.21	0.21	0.12	0.42
C.D. (P=0.05)	0.82	0.03	0.67	0.68	0.39	NS
Nutrient management practices						
N_1: Organic farming	44.43	0.59	19.26	29.90	13.20	21.60
N_2: Natural farming	42.89	0.54	17.36	28.61	12.22	20.92
N_3: Integration of both	45.75	0.64	20.10	30.74	13.64	21.96
SEm±	0.13	0.01	0.21	0.22	0.14	0.40
C.D. (P=0.05)	0.46	0.03	0.73	0.75	0.41	NS
Interaction						
SEm±	0.45	0.01	0.38	0.26	0.25	0.61
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

Table 3: Yield of chickpea (kg ha^{-1}) as influenced by intercropping systems and organic nutrient modules during 2022-23, 2023-24 and pooled.

Treatment	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Biological yield (kg ha^{-1})		
	2022	2023	pooled	2022	2023	pooled	2022	2023	pooled
Cropping systems									
C_1: Chickpea (sole)	1866	1797	1831	2585	2560	2573	4451	4357	4404
C_2: Chickpea + coriander (2:2)	908	873	890	1270	1242	1256	2178	2114	2146
C_3: Chickpea + linseed (2:2)	766	732	749	1150	1091	1121	1916	1824	1870
C_4: Chickpea + sorghum (2:2)	691	591	641	1079	930	1004	1770	1522	1645
Nutrient management practices									
N_1: Organic farming	1075	1021	1048	1533	1481	1507	2608	2503	2555
N_2: Natural farming	949	901	925	1407	1389	1398	2356	2290	2323
N_3: Integration of both	1149	1072	1111	1622	1497	1560	2772	2569	2671
GM	1058	988	1028	1521	1456	1488	2579	2454	2516

504, 437 and 1457 kg ha^{-1} during 2022-23, 489, 416 and 1278 kg ha^{-1} during 2023-24 and 497, 427 and 1367 kg ha^{-1} in pooled data.

Straw yield (kg ha^{-1})

The total straw yield of chickpea was recorded with sole chickpea (2585, 2560 and 2573 kg ha^{-1}) during 2022-23, 2023-24 and pooled respectively. In the intercropping system, highest straw yield of chickpea was observed when intercropped with the coriander (1270, 1242 and 1256 kg ha^{-1}) during 2022-23, 2023-24 and pooled respectively. Whereas straw yield of chickpea among different organic nutrient modules was recorded highest with integration of both natural and organic farming (1622 and 1497 kg ha^{-1}) during 2022-23 and 2023-24 respectively. The mean straw yield of various intercrops such as coriander, linseed and sorghum were recorded to be in 916, 1144 and 3177 kg ha^{-1} during 2022-23, 864, 1102 and 2856 kg ha^{-1} during 2023-24 and 890, 1123 and 3017 kg ha^{-1} in pooled data.

Biological yield (kg ha^{-1})

The highest biological yield of chickpea was noted in sole chickpea (4451 and 4357 kg ha^{-1}) during 2022-23 and 2023-24 respectively. In the intercropping system, highest biological yield of chickpea was observed when intercropped with the coriander 2178 and 2114 kg ha^{-1} during 2022-23 and 2023-24 respectively. Where as biological yield of chickpea among different organic nutrient modules was recorded highest with integration of both natural and organic farming 2772 and 2569 kg ha^{-1} during 2022-23 and 2023-24 respectively. The mean biological yield of various inter crops such as coriander, linseed and sorghum were recorded to be in 1420, 1581 and 4633 kg ha^{-1} during 2022-23 and 1353, 1518 and 4384 kg ha^{-1} during 2023-24.

CONCLUSION

On the basis of 2 years of study it can be inferred that chickpea sole with integration of both organic and natural farming practices proved significantly better in terms of growth, yield attributes and yield. Therefore, chickpea sole with integration of both organic and natural farming practices can be recommended for inclusion under package of practices for farmers of Vidarbha region of Maharashtra.

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Conflict of interest

On behalf of the authors whose names are listed below I certify that we have no conflict of financial and non-financial interest in the subject matter or materials discussed in this manuscript.

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