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Effect of chickpea based intercrops and organic nutrient modules on soil physico chemical properties

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Abstract
The overuse of chemical fertilizers following the Green Revolution has degraded soil fertility, leading to the loss of vital flora, fauna, and micronutrients. Organic farming has emerged as a sustainable alternative to maintain soil health, increase the soil carbon pool, and meet food demands. However, in India, organic farming remains largely export-oriented. The rise in awareness about environmental conservation and the health risks of agrochemicals has spurred interest in organic agriculture globally. Natural Farming (NF), particularly Zero Budget Natural Farming (ZBNF), offers an agroecology-based system that reduces costs and promotes biodiversity. A field experiment conducted during the rabi season of 2022-23 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, studied the effects of different organic modules on chickpea-based intercropping systems. The results highlight the potential of integrating organic and natural farming methods to enhance yield and sustainability.

Keywords: Green revolution, soil fertility, organic farming, Natural Farming (NF), Zero Budget Natural Farming (ZBNF), chickpea (*Cicer arietinum*)

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.

Natural Farming (NF) is considered to be agro ecology based diversified farming system, which integrates crops, trees and livestock, allowing functional biodiversity (Rosset and Martinez-Torres, 2012) [11] to drastically cut down production costs by replacing the chemical fertilizers and pesticides with home-grown product like Jeevamritham, Beejamritham, Neemastra etc., and adopting intercropping and mulching (Palekar, 2005; 2006) [8, 9]. Highlighting the predominance of smallholder farmers (68.5 per cent marginal and 17.7 per cent small farmers) in India, The Economic Survey (2019) emphasised 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) [3] and "probiotic" (Lorimer, 2017) [6] understandings of soil and plant life are also an inspiration for the ecological renewal of agriculture

Chickpea (*Cicer arietinum*) the most important pulse crop of *rabi* season, is cultivated mainly in semiarid 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. Production of chickpea in India was 11.35 MT (Anonymous d, 2019 2020) [1]. Area under chickpea cultivation in Maharashtra was 2043.21 thousand ha and production under *rabi* 2019-2020 was 2240.09 thousand tonnes. Chickpea productivity in Maharashtra in *rabi* was 1096.36 kg ha^{-1} (Anonymous e, 2019-2020) [1]. Chickpea contains 21% protein, 61% carbohydrate and 2.2% oil (Gupta, 1988) [4]. It contains high quality protein and is suited for animal feed as well as for human diet.

Materials and Methods

A field experiment was conducted during rabi season of 2022-23 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 + Bijamrith + Jivamrith + Neemastra) and N3: Integration of Organic farming and Natural farming - (Biofertiizer + Vermicompost + Jivamrith + Neemastra) replicated thrice. Sowing was done by dibbling on 13th Nov 2022. Data was analyzed by analysis of variance.

Results

1. pH

Soil pH is a key characteristic that can used to make informative analysis on both qualitative and quantitative. The data relevant to soil pH on initial and after harvest in both seasons and mean value of both seasons was presented in Table 1.

The data presented in the table revealed that there was slight difference observed between the initial and final values of soil pH in both the seasons. The initial soil pH status (7.91, 7.95 and 7.93) in 2022, 2023 and mean values respectively, there was no significant difference recorded in between different cropping systems, which was ranged in between 7.77 to 7.83 in 2022-23, 7.74 to 7.84 in 2023-24 and the mean values ranged between 7.75 to 7.86. Sole cropping of chickpea obtained low pH value as compared to other cropping systems. Whereas, intercropping treatments with chickpea recorded better pH status over its sole cropping. This is due to organic matter decomposition in intercropping system due to application of vermicompost and also due to chickpea released acids from roots and led to decline soil pH over its sole cropping reported by (Li *et al*., 2018) [5]. Therefore, the reduction of soil pH in intercropping due to legumes in intercropping systems and enhanced cation removal from soil due to over yielding in the intercropping system. Poddar *et al*., (2017) [10] reported the similar result of reduction of pH after harvest of crop.

When different organic nutrient modules were considered showed non-significant effect in both the seasons and in the mean. The results ranged between 7.80 to 7.83 in 2022-23, 7.79 to 7.80 in 2023-24 and the average of both seasons ranged between 7.79 to 7.81.

Chickpea crop have ability to reduce the pH of the soil in rhizosphere and make the micro-environment favourable. Since pulses acquire a greater part of their nitrogen requirement from the air as diatomic nitrogen rather than from the soil as NO^{-}_{3} their net effect is to lower the pH of the soil. Ganeshamurthy *et al*., (2006) [2] reported the similar result.

2. EC (dSm^{-1})

Soil EC is a measure of concentration of ions from water soluble salts in soils and the test results are indicative of soil salinity. The data relevant to electrical conductivity of initial and final status of soil in both the seasons was recorded in the Table 51.

The data presented in the table revealed among different cropping systems there was no significant difference was seen in both the seasons. The initial values of EC were recorded to be 0.23, 0.21 and 0.22 in 2022, 2023 and the average of both seasons respectively. Among different cropping systems EC values were recorded to be in the range of 0.18 to 0.19 in 2022-23, 0.18 to 0.20 in 2023-24 and the mean of both seasons ranged between 0.19 to 0.20.

Among different organic nutrient modules the results recorded shown that there was no significant difference was noted and the EC values ranged between 0.18 to 0.19 in 2023-24, 0.20 to 0.21 in 2023-24 and in the mean ranged between 0.19 to 0.20.

Interaction effect in between cropping systems and organic nutrient modules was also found to be non-significant.

3. Organic carbon (%)

Soil organic carbon is a measurable component of soil organic matter and refers to the carbon content of organic compounds. The data recorded for organic carbon status as influenced by different intercropping systems and organic nutrient modules was presented in the Table 51.

The initial values of OC were noted to be 4.60, 4.90 and 4.70 in 2022-2023 and the mean of both years respectively.

When different intercropping systems were considered, there was no significant difference was observed and the values of OC ranged in between 4.60 to 4.90 in 2022-23, 4.80 to 4.90 in 2023-24 and the mean ranged in between 4.80 to 4.90. Among the different organic nutrient modules the results revealed that there was no significant difference and values ranged in between 4.70 to 4.80 in 2022-23, 4.80 to 4.90 in 2023-24 and the mean ranged between 4.80 to 4.90. Interaction effect in between cropping systems and organic nutrient modules was also found to be non-significant.

This might be due to application of vermicompost at the time of sowing which increases soil organic carbon content than initial status and also due to left over residue of chickpea after harvest which ultimately increases organic matter content in the soil. Similar results reported by Mahapatra *et al*., (2006) [7]. As compared to initial organic carbon status of soil increased in organic carbon notified after harvest of crop. Higher values of soil organic carbon promote soil structure or tilth which provides greater physical stability. These results confirm the findings of Poddar *et al*., (2017) [10].

4. Available nitrogen, phosphorus and potassium (kg ha^{-1})

The data presented in the Table 52 for available nitrogen, available phosphorous and available potassium revealed that after harvest of the crops available N, P and K content increases in almost all the treatments from the initial status in both the seasons.

The initial available nitrogen was recorded to be 215.23, 223.20 and 219.22 kg ha^{-1} in 2022, 2023 and the mean of both seasons respectively.

Among different cropping systems significantly higher amount of available nitrogen was observed in sole chickpea (237.95, 235.16 and 236.56 kg ha^{-1}) in 2022-23, 2023-24 and the pooled respectively, which was followed by chickpea + coriander (2:2) and chickpea + linseed (2:2). Lowest available nitrogen found in chickpea + sorghum (2:2). It was due to legume (chickpea) grow in a symbiotic relationship with soil dwelling bacteria. The bacteria take gaseous nitrogen from air in the soil and feed this nitrogen to legumes which makes nitrogen available in the soil and provides nitrogen to other non legume crops. Tanwar *et al.*, (2011) [12] reported the effect of intercropping row ratio and fertility levels on chickpea and linseed intercropping system. Between the treatments highest N uptake was recorded under sole chickpea over its intercropping system. Poddar, *et al*., (2017) [10] reported that sole chickpea recorded higher nitrogen content after harvest as compared to the initial nitrogen status which may be due to their leguminous in nature and fixation of atmospheric nitrogen by the formation of nodules.

Among various nutrient modules the highest available nitrogen was recorded in integration of both natural and organic farming (235.55, 234.80 and 235.18) in 2022-23, 2023-24 and the pooled which was statistically superior over natural and organic farming treatments when applied individually.

The interaction effect was found to be non- significant.

Phosphorous

The initial available phosphorous was recorded to be 13.68, 15.26 and 14.47 kg ha^{-1} in 2022, 2023 and the pooled of both seasons respectively.

When different intercropping systems were considered, there was no significant difference was observed and the values of available phosphorus ranged in between 13.69 to 16.99 kg ha^{-1} in 2022-23, 14.33 to 16.65 kg ha^{-1} in 2023-24 and the mean ranged in between 14.01 to 16.79 kg ha^{-1}.

Among the different organic nutrient modules the results revealed that there was no significant difference and values ranged in between 13.67 to 16.68 kg ha^{-1} in 2022-23, 14.40 to 16.02 kg ha^{-1} in 2023-24 and the mean ranged between 14.04 to 15.22 kg ha^{-1}. Interaction effect in between cropping systems and organic nutrient modules was also found to be non-significant.

Potassium

The initial available potassium was recorded to be 339.36, 326.36 and 332.86 kg ha^{-1} in 2022, 2023 and the pooled of both seasons respectively.

When different intercropping systems were considered, there was no significant difference was observed and the values of available potassium ranged in between 316.00 to 328.98 kg ha^{-1} in 2022-23, 317.63 to 330.09 kg ha^{-1} in 2023-24 and the mean ranged in between 316.82 to 329.54 kg ha^{-1}.

Among the different organic nutrient modules the results revealed that there was no significant difference and values ranged in between 316.21 to 329.64 kg ha^{-1} in 2022-23, 313.98 to 332.95 kg ha^{-1} in 2023-24 and the mean ranged between 315.10 to 331.29 kg ha^{-1}. Interaction effect in between cropping systems and organic nutrient modules was also found to be non-significant.

Table 1: Soil physico-chemical properties of experimental site at initial and after harvesting of various crops as influenced by different cropping systems and organic integrated nutrient modules during 2022-23 and 2023-24

Treatment	pH			EC (dS m^{-1})			OC (g kg^{-1})		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
Initial	7.91	7.95	7.93	0.23	0.21	0.22	4.60	4.90	4.70
Cropping systems									
C_1: Chickpea (sole)	7.83	7.89	7.86	0.19	0.22	0.20	4.90	4.90	4.90
C_2: Chickpea + coriander (2:2)	7.80	7.77	7.78	0.18	0.18	0.18	4.60	4.90	4.80
C_3: Chickpea + linseed (2:2)	7.77	7.74	7.75	0.18	0.20	0.19	4.70	4.80	4.80
C_4: Chickpea + sorghum (2:2)	7.83	7.79	7.81	0.18	0.21	0.19	4.80	4.90	4.90
SEm±	0.04	0.06	0.03	0.01	0.01	0.01	0.01	0.01	0.01
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management practices									
N_1: Organic farming	7.80	7.80	7.80	0.18	0.20	0.19	4.80	4.90	4.90
N_2: Natural farming	7.83	7.80	7.81	0.18	0.20	0.19	4.70	4.90	4.80
N_3: Integration of both	7.80	7.79	7.79	0.19	0.21	0.20	4.80	4.80	4.80
SEm±	0.03	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
SEm±	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
SEm±	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Available NPK status (kg ha^{-1}) of experimental site at initial and after harvesting of various crops as influenced by different cropping systems and organic integrated nutrient modules during 2022-23 and 2023-24

Treatment	N (kg ha^{-1})			P_2O_5 (kg ha^{-1})			K_2O (kg ha^{-1})		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
INITIAL	215.23	223.20	219.22	13.68	15.26	14.47	339.36	326.36	332.86
Cropping systems									
C_1: Chickpea (sole)	237.95	235.16	236.56	16.93	16.65	16.79	328.98	330.09	329.54
C_2: Chickpea + coriander (2:2)	236.64	233.48	235.06	15.26	15.42	15.34	324.13	325.89	325.01
C_3: Chickpea + linseed (2:2)	227.34	226.59	226.97	14.63	14.71	14.67	321.30	323.38	322.34
C_4: Chickpea + sorghum (2:2)	207.76	201.72	204.74	13.69	14.33	14.01	316.00	317.63	316.82
SEm±	1.30	1.08	1.14	1.15	0.65	0.96	2.83	4.87	5.21
C.D. (P=0.05)	4.17	3.45	3.64	NS	NS	NS	NS	NS	NS
Nutrient management practices									
N_1: Organic farming	228.23	224.87	226.55	15.03	15.41	15.22	321.96	325.82	323.89
N_2: Natural farming	223.49	219.55	221.52	13.67	14.40	14.04	316.21	313.98	315.10
N_3: Integration of both	230.55	228.30	229.43	16.68	16.02	16.35	329.64	332.95	331.29
SEm±	0.50	0.79	1.03	0.89	0.57	0.79	3.10	4.58	5.76
C.D. (P=0.05)	1.74	2.35	2.11	NS	NS	NS	NS	NS	NS
Interaction									
SEm±	0.49	0.46	0.55	0.41	0.23	0.36	2.95	2.37	2.61
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

From the above study it was clear that chickpea sole with integration of natural and organic management practices gave the best results among all other treatments and this was at par with chickpea + coriander (2:2) when applied with integration of both natural and organic farming treatments.

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