Original Research Article

Effect of Conservation Tillage on Soil Fertility, Yield and Nutrient Uptake by Chickpea in Soybean-Chickpea Sequence on Vertisols

Abstract

A field study entitled, “Effect of conservation tillage on soil fertility, yield and nutrient uptake by chickpea in soybean-chickpea sequence on Vertisols” was conducted during *rabi* 2021-22 at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The soil of the experimental site was Vertisol which was moderately alkaline in reaction, low in nitrogen, medium in available phosphorus and high in available potassium. The five treatments replicated four times in randomized block design comprised of conventional tillage with crop residue mulch, conventional tillage without crop residue mulch, reduced tillage with crop residue mulch, zero tillage with crop residue mulch, permanent BBF with crop residue mulch. The results indicated that the conservation tillage involving reduced tillage *i.e.* pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch resulted in improvement in soil fertility, higher nutrient uptake and yield of chickpea grown in Vertisols under rainfed conditions.

Statistical data for the initial and improved nitrogen and phosphorus and potassium.

Keywords: Conservation tillage, nutrient uptake, reduced tillage, soil Fertility, zero tillage.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the oldest pulse cash crop and cultivated throughout India since ancient times. It is one of the promising pulse crop grown for grain and green vegetables mainly during *rabi* season in September-November and harvested in February-April. In India Chickpea is popularly known as “Gram” or “Bengal Gram” or “Chana” or "Egyptian pea", which belonged to Leguminosae family. It contains 21% protein, 2.2% fat and 62% carbohydrates. It is consumed as vegetable as well as fodder for livestock/animals. Chickpea is one of the major *rabi* pulse crop which has high

digestible dietary iron, niacin, vitamin C and B. Its leaves contain malic acid which is very useful stomach ailments and for blood purification.

Chickpea has capacity to fix atmospheric nitrogen and add sizeable amount of nitrogen to the soil, so it plays an important role sustaining soil productivity. It is also a good source of carbohydrates, dietary fiber, minerals, vitamins, and several bioactive components and is also known as the poor man's meat. It plays an important role in the improvement of nutrition by complementing the cereal-based foods.

Chickpea is gaining importance as a functional food due to its several health benefits such as cholesterol control, prevention of type-2 diabetes, anti-cancerous activity, and weight loss. Crop duration is 90-120 days, depending on the variety. It is best suited to areas having low to moderate rainfall of 600-900 mm per annum and mild-cold weather.

India is the largest producer of chickpea followed by Pakistan, Turkey and Iran. India produces around 10 to 11 million tonnes and contributes around 70% of the total world production. In India about 112.01 lakh ha (276.78 lakh acres) area coverage was reported under chickpea during *rabi* 2022-23 as against 114.18 lakh ha (282.14 lakh acres) during the same period in 2021-22. The states of Maharashtra 29.16 lakh ha, Rajasthan 21.43 lakh ha, Madhya Pradesh 22.08 lakh ha, Karnataka 11.84 lakh ha are the major producers of chickpea in India. According to Government 2nd advance estimates, all India chickpea production in 2022-23 was at 13.63 million tonnes (Anonymous, 2023). In Maharashtra, area, production and productivity of chickpea during 2021-22 was estimated as 28.3 lakh ha, 32.8 lakh tonnes and 1156 kg ha^{-1} respectively (Anonymous, 2022).

Conservation tillage is a farming system which promotes minimum soil disturbance, maintenance of permanent soil cover and diversification of plant species. In conservation tillage minimum soil disturbance takes place which is essential to maintain minerals within the soil, stopping erosion and preventing water loss from occurring within soil.

It is believed that tilling the soil would increase fertility within the soil through mineralization that takes place in soil. Conservation tillage includes a

range of residue management and no till or reduced tillage practices. Conservation tillage practices have been shown to promote SOC sequestration most notably in shallow surface soil (Chambers *et al*., 2016). It leaves sufficient crop residue to cover the soil surface by at least 30% which increase water retention, soil C and N, and potentially crop yield.

Materials and Methods

With a view to study the effect of conservation tillage on soil fertility, yield and nutrient uptake by chickpea in soybean-chickpea sequence on Vertisols, a field experiment was initiated during 2017-18 and the present study was conducted during 2021-22 on the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola, Maharashtra. The soil of experimental site was Vertisols which belongs to fine, smectitic, hyperthermic family of Typic Haplusterts. The representative soil samples (0-20 cm) were collected from all the plots at harvest of chickpea crop. Experimental soil was nearly neutral to slightly alkaline in nature pH (7.69), with organic carbon (5.3 g kg^{-1})and electrical conductivity (0.30 dSm^{-1}), available nitrogen (175.4 kg ha^{-1}) was low, available phosphorus was low (17.9 kg ha^{-1}), available potassium was (291.6 kg ha^{-1}) and soil was sufficient in available micronutrients.

Add supporting photograph of the experimental site

This experiment was conducted with five treatments and four replications laid out in a randomized block design at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The different treatments were Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch (T_1), Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T_2), Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T_3), Zero tillage + crop residue mulch (T_4), Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch (T_5). The variety Jaki-9218 was sown in the present investigation. The general recommended dose of fertilizers 20:40:30 N, P_2O_5, K_2O kg ha^{-1} was used. The plant samples of chickpea seed and straw were collected at the time of harvest and analyzed for nutrient content and uptake of nutrients and plot wise chickpea and straw yields were recorded.

Results and Discussion

Effect of conservation tillage on chickpea yield

Among the various treatments, the significantly higher chickpea seed yield (1658 kg ha^{-1}) was observed in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide

application + crop residue mulch (T_3) and was on par with conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch (T_1). The lowest chickpea seed yield (1330 kg ha^{-1}) was recorded in treatment zero tillage + crop residue mulch (T_4). The increase in chickpea seed yield in T_3 was 10.2% and 24.6% higher as compared to conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T_2) and zero tillage + crop residue (T_4) respectively.

Higher chickpea straw yield (1902 kg ha^{-1}) was recorded in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T_3) and was on par with treatment T_1 *i.e.* conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch. The lowest chickpea straw yield (1533 kg ha^{-1}) was recorded with zero tillage + crop residue mulch (T_4). The increase in chickpea straw yield in reduced tillage (RT) - pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch (T_3) was 15.4% and 24% higher as compared to conventional tillage (CT) - pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch (T_2) and zero tillage + crop residue mulch (T_4) respectively. Higher chickpea yield in reduced tillage may be due to incorporation of crop residue which undergo decomposition, during which series of nutrient transformation takes place due to increase in microbial activity which helps in higher nutrient availability to the crops and higher uptake of nutrients by the crops will result in higher yield. The results are in conformity with the findings Age *et al.* (2019), Patode *et al*. (2021) and Singh *et al*. (2022).

Table 1. Effect of conservation tillage on chickpea yield

Treatments		**Chickpea yield (kg ha^{-1})**	
		Seed	**Straw**
T_1	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	1594	1773
T_2	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	1504	1647

T_3	Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	1658	1902
T_4	Zero tillage + crop residue mulch	1330	1533
T_5	Permanent broad bed furrow + pre-emergence herbicide application + crop residue mulch	1386	1570
SE(m±)		24.06	27.95
CD (5%)		74.95	87.08

Effect of conservation tillage on nutrient uptake by chickpea

Significantly higher total N uptake (74.76 kg ha^{-1}), P uptake (15.24 kg ha^{-1}) and K uptake (33.97 kg ha^{-1}) by chickpea was observed in reduced tillage with crop residue mulch (T_3) and N and P uptake was on par with conventional tillage with crop residue mulch (T_1). The increase in total N, P and K uptake by chickpea was 15%, 19.90% and 18.15% respectively in treatment T_3 as compared to conventional tillage without crop residue mulch (T_2), whereas the increase in total N, P and K uptake by chickpea was 40%, 75.77% and 44.92% respectively in treatment T_3 as compared to treatment zero tillage with crop residue mulch (T_4). The higher nutrient uptake in reduced tillage is due to decomposition of crop residue which increases microbial activity which in turn help in mineralization and slow release of nutrients to chickpea crop resulting in higher uptake of nutrients. The results are in conformity with the findings of Dixit *et al.* (2015) and Age *et al.* (2019).

Table 2. Effect of conservation tillage on nitrogen, phosphorus and potassium uptake by chickpea

Treatments		Total nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	71.23	15.24	31.84
T_2	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	64.99	12.71	28.75
T_3	Reduced tillage (RT)- Pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	74.76	15.24	33.97
T_4	Zero tillage + crop residue mulch	53.14	8.67	23.44

T_5	Permanent Broad bed furrow + Pre-emergence herbicide application + crop residue mulch	57.01	11.40	27.07
SE(m±)		1.19	0.36	0.67
CD (5%)		3.65	1.10	2.07

Effect of conservation tillage on physical and chemical properties of soil

Data pertaining to the bulk density of soil as influenced by various treatments was significant and it ranged from 1.40 to 1.45 Mg m^{-3}, indicating that the lowest (1.40 Mg m^{-3}) bulk density was recorded with reduced tillage with crop residue mulch (T_3) and was on par with treatments T_2 and T_5. The higher value of bulk density (1.45 Mg m^{-3}) was found in treatment T_4 *i.e.* zero tillage with crop residue mulch. The results are in conformity with the findings of Das *et al.* (2020), Kumawat *et al.* (2020) and Kumari *et al.* (2021). Hydraulic conductivity of soil ranged from 0.78 to 0.86 cm hr^{-1} and the higher hydraulic conductivity (0.86 cm hr^{-1}) was recorded in reduced tillage with crop residue mulch (T_3) and was on par with conventional tillage with crop residue mulch (T_1). The lower value of hydraulic conductivity (0.78 cm hr^{-1}) was found in treatment T_4 *i.e.* zero tillage with crop residue mulch. The results are in conformity with the findings of Sharma *et al*. (2016).

Table 3. Effect of conservation tillage on physical and chemical properties of soil

Treatments		Physical properties		Chemical properties		
		BD (Mg m^{-3})	HC (cm hr^{-1})	pH (1:2.5)	EC (dSm^{-1})	OC (g kg^{-1})
T_1	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	1.41	0.83	7.62	0.26	6.09
T_2	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	1.43	0.82	7.65	0.28	5.56
T_3	Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	1.40	0.86	7.59	0.25	6.17
T_4	Zero tillage + crop residue mulch	1.45	0.78	7.64	0.28	5.79
T_5	Permanent broad bed furrow + pre-emergence herbicide	1.44	0.82	7.61	0.26	5.78

	application + crop residue mulch					
SE(m±)		0.01	0.01	0.01	0.01	0.07
CD (5%)		0.03	0.03	0.03	0.02	0.20

The pH of soil ranged from 7.59 to 7.65, while EC ranged between 0.25 to 0.28 dSm^{-1}, indicating that soil was slightly alkaline in reaction and EC limits were safer for the crop growth and development. Lower pH (7.59) and electrical conductivity (0.25 dS m^{-1}) was recorded in reduced tillage with crop residue mulch (T_3). Further, it was observed that, all the treatments where crop residue was retained except T_2, had lower values of soil pH and EC. The results are in conformity with the findings of Kumar *et al*. (2017).

Highest organic carbon content (6.17 g kg^{-1}) was observed in reduced tillage with crop residue mulch (T_3) and was on par with conventional tillage with crop residue mulch T_1 (6.09 g kg^{-1}). Lowest organic carbon content in soil was observed in conventional tillage with no crop residue mulch (T_2). The increase in organic carbon content in T_3 was 10.9% higher as compared to conventional tillage with no crop residue mulch (T_2). The higher values of organic carbon content is due to the direct incorporation of crop residues, which encourages the proliferation in soil microbial environment which might have resulted in the increased organic carbon content. The results are in conformity with the findings of Kushwa *et al.* (2016), Somasundaram *et al.* (2019) and Naderi *et al*. (2021).

Effect of conservation tillage on soil fertility

Available nutrient status of soil indicated that significantly higher available N (187.29 kg ha^{-1}), available P (21.96 kg ha^{-1}) and available K (301.49 kg ha^{-1}) were observed in treatment T_3 (reduced tillage with crop residue mulch) which was on par with conventional tillage with crop residue mulch (T_1). The increase in available N content (0.66% and 3.50%), available P content (3.9% and 17.2%) and available K content (0.42% and 1.6%) were recorded in reduced tillage with crop residue mulch (T_3) as compared to treatment T_1 and T_2 respectively. The increase in available nutrients in reduced tillage with crop residue mulch (T_3) may be due to addition of soybean crop residue. Crop residue addition have improved the soil physical conditions and microbial activity in the

soil. The results are in conformity with the findings of Kumar *et al*. (2017) and Das *et al*. (2020).

Table 4. Effect of conservation tillage on available nutrients in soil

Treatments		Available nutrients (kg ha^{-1})		
		N	P	K
T_1	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + crop residue mulch	186.06	21.13	300.20
T_2	Conventional tillage (CT)- pre-sowing harrowing + one hoeing + one hand weeding + No crop residue mulch	180.95	18.73	296.48
T_3	Reduced tillage (RT)- pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch	187.29	21.96	301.49
T_4	Zero tillage + crop residue mulch	182.40	19.94	297.20
T_5	Permanent Broad bed furrow + Pre-emergence herbicide application + crop residue mulch	184.03	20.11	298.61
SE(m±)		0.69	0.38	0.63
CD (5%)		2.14	1.16	1.94

Conclusion

Thus, from the study it can be concluded that, conservation tillage involving reduced tillage, *i.e.* pre sowing harrowing + broad bed and furrow every year + pre-emergence herbicide application + crop residue mulch resulted in improvement in soil fertility, higher nutrient uptake and yield of chickpea grown in Vertisols under rainfed conditions.

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