Impact of using Fertilizers and Tillage Management in Oryza Sativa - Cicer Arietinum Cropping System

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Abstract*: *With an intention to study the impact of the ferlizers, tillage management and irrigation techniques used for raising chickpea (Cicer arietinum L.) after the cultivation of rice (Oryza sativa L.), an on-field examination was conduction at the Experimental Farm, Annamalai University in 2018. Under the treatment criteria of 30:60:40 kg NPK/ha along with deep ploughing (23 cm deep) with spade and cumulative pan evaporation (CPE) of 60 mm, significant increase in growth and yield sttibutes of chickpea was observed compared to that of 20:40:40 kg NPK/ha with normal ploughing and CPE of 80 mm. The former treatment also resulted in the significant increase in the yield rate of chickpea and chickpea-equivalent in comparison to the later treatment process. The monetary returns also increased. On the other hand, the deep ploughing (23cm deep) with spade recorded a significant higher grain and straw production of chickpeas along with chickpea-equivalent yield and monetary profit in comparison to the normal ploughing technique. Different tillage and nutrients management techniques showed a great impact on varied physical properties. Moreover, an outstanding impact was reported during the rabi season in case of the preceding crop (rice) in the following year.

Index Terms*: *Cropping system, Monetary returns, Tillage Water-use efficiency.

I. INTRODUCTION

Rice-chickpea is one of the principal cropping system in the North Indian part after the rice-wheat cultivation cycle. The addition of pulses (chickpea) in the rice-wheat cropping system resulted in increasing the overall productivity of the system and improving the physical as well as the chemical features of the soil. The prime reason behind such significant increase is due to the increase in the production due to the N that was rescued from the fertilizer source and soil fertility procedure through biological source of N [1, 2]. Continuous growing of rice in the same field not only disturbs the physical condition of the soil but also causes great depletion of nutrients due to higher demand of rice plant and loss by leaching. Hence deep tillage practice improves physico-chemical properties of soil, providing good nutrient opportunity to the succeeding crops in rice-chickpea cropping system. Irrigation also plays a vital role in not only increasing the productivity of chickpea but also improving the physico-chemical properties of soil in intensive cropping systems. Hence, an experiment was laid out to study the nutrient management and tillage practices on growth, yield, physical properties of soil, moisture utilization pattern and nutrients uptake by chickpea in rice-chickpea cropping system under varying irrigation levels.

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II. MATERIALS AND METHODS

With an intention to study the impact of the ferlizers, tillage and irrigation management techniques used for raising chickpea (*Cicer arietinum* L.) after the cultivation of rice (*Oryza sativa* L.), an on-field examination was conduction at the Experimental Farm, Annamalai University in 2018. The treatment combination comprising chickpea crop with 2 levels of nutrients (20:40:40 kg NPK/ha and 30:60:40 kg NPK/ha), 2 levels of tillage practices, i.e. normal ploughing as well as deep ploughing with spade and 2 irrigation levels, *viz.*, CPE of 60 mm and 80 mm. However, rice crop was raised with recommended package of practices during both the years. The experiment was performed in factorial randomized block design with 3 replications. The experiment was conduced on fixed site. The experimental field was sandy loam in organic carbon (0.31%) and available nitrogen (251 kg/ha) and medium in available phosphorus (17.4 kg/ha) and potassium (202 kg/ha). Chickpea was irrigated thrice in CPE of 60 mm and once in CPE of 80 n in first year; however 2 irrigations in CPE of 60 mm and 1 irrigation in CPE of 80 mm were given during second year. Total rainfall received during the cropping season as 683 and 780 mm during 2000-01 and 2001-02, respectively.

III. RESULTS AND DISCUSSION

A. Effect of fertilizers

There was a significant increase in the physical features of chickpea (i.e. plant height, functional leaves, and dry matter per plant) due to the application of 30:60:40 kg NPK/ha compared to 20:40:40 kg NPK/ha (Table 1). Application of 30 60:40 kg NPK/ha significantly reduced the mean number and dry weight of root nodules compared to 20:40:40 kg NPK/ha. Pods/plant and 100 seed weight of chickpea were significantly increased with application of 30:60:40 kg NPK/ha compared to 20:40:40 kg NPK/ha.

There was a significant

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increase in the grain and straw yields of chickpea and chickpea-equivalent yield due to the application of 30:60:40 kg NPK/ha in comparison to the 20:40:40 kg NPK/ha. The application of 30:60:40 kg NPK/ha resulted in the increased rate of grain and straw yields of chickpea and chickpea-equivalent yield over 20:40:40 kg NPK/ha, i.e. 15.5, 15.2 and 13.4%, respectively. Increase in the net economy was recorded to be more in 30:60:40 kg NPK/ha application compared to 20:40:40 kg NPK/ha. Patil *et al.* reported that rice yield of resource-poor farmers can be improved by including legumes and by effective capturing of biologically fixed N and soil N through direct-seeded rice system in rain-fed lowlands [3]. Bhagat and Dhar concluded that the yield of rice, chickpea and rice-equivalent yields as well as the net returns improved by using rice cv. TR 36' along with 80 kg N + 40 kg P_2O_5+ 20 kg K_2O/ha and followed by chickpea given 20 kg N + 60 kg P_2O_5/ ha in the rice-chickpea cropping system [4].

Application of 30:60:40 kg NPK/ha slightly decreased bulk density, particle density and water-holding capacity of the soil while pore space and volume of expansion were increased than application of 20:40:40 kg NPK/ha (Table 2).

30:60:40 kg NPK/ha resulted in the significant increase in the level of nitrogen, phosphorus, and potassium uptake of the crops (rice and chickpea) compared to that of the 20:40:40 kg NPK/ha application (Table 4). 30:60:40 kg NPK/ha application also recorded significant increase in the total N,P,K uptake of the system compared to the 20:40:40 kg NPK/ha. A significant increases in the N con¬tent was recorded during 20:40:40 NPK/ha application, whereas there was a significant increase in the phosphorus and potassium content in the selected crops with the 30:60:40 kg NPK/ha application.

B. Effect of tillage

A significant increase in the plant height, number of functional leaves, dry matter/plant; total number and dry weight of root nodules/plant was recorded with the deep ploughing (23 cm deep) with spade compared to the normal ploughing (Table 1). Pods per plant rate and 100-seed weight parameters of chickpea in deep ploughing with spade were more compared to the normal ploughing.

Grain and straw yields of chickpea and chickpea-equivalent yield were also higher in deep ploughing with spade (23 cm deep) compared to normal ploughing in the respective years. The deep ploughing resulted in grain and straw yields of chickpea and chickpea-equivalent yields of 14.9, 10.0 and 10.9%, respectively compared to the normal ploughing. Maximum net return and benefit : cost ratio were recorded in deep ploughing with spade (23 deep) compared to normal ploughing.

The varied features like bulk density and particle density was reduced due to the deep ploughing; whereas the water-holding capacity, pore space and expansion volume of the soil in normal ploughing was found to be increased (Table 2).

The N & K uptake by rice and chickpea was high with the deep ploughing (23 cm deep) technique by using spade in comparison to normal ploughing (3 ploughings with harrow), respectively (Table 4). In rice-chickpea cropping system, the deep tillage management recorded a significant increase in the total nitrogen, phosphorus and potassium uptake compared to the normal tillage practices. N, P and K content in rice and chickpea was more in deep ploughing than that of normal ploughing.

C. Effect of irrigation

Mean plant height, number of functional leaves, and dry matter/plant was found to be more in Cumulative pan evaporation (CPE) of 60 mm than that of 80 mm (Table 1). Application of more number of irrigation, *i.e.* CPE of 60 mm, significantly reduced the number and dry weight of root nodules compared to CPE of 80 mm. Three irrigations given at CPE of 60 mm proved beneficial in increasing all the yield attributes of chickpea than 2 irrigations given at CPE of 80 mm.

Significantly higher grain and straw yields of chickpea and chickpea-equivalent yield were obtained with 3 irrigations given at CPE of 60 mm than CPE of 80 mm (Table 1). The rate of grain and straw yield of chickpea and chickpea-equivalent production with CPE of 60 mm was high, i.e. 29.2, 15.2 and 18.7%, compared to that of 80 mm, respectively. The CPE of 60 mm recorded maximum net return and benefit: cost ratio than CPE of 80 mm. The result of the present study was in affirmative state with those of Patil *et al.*, and Bhagat and Dhar, who worked on rice and pulse-based cropping systems [3,4]. Sarkar *et al.* found that the highest returns and benefit: cost ratio were achieved with rice-chickpea sequences than single cropping system [5]. The physical properties of the soil after harvest of second year crop did not show much variation with various irrigation schedules (Table 2).

Table 1. Growth and yield attributes, yield and economics of chickpea as influenced by different treatment in rice-chickpea system

Treatment	Plant height (cm)	No. of functional leaves/plant	Dry matter/ plant (g)	No. of effective root nodules	Dry weight of root nodules (g)	Pods/ plant	100-seed weight (g)	Yield of rice (q/ha)		Yield of chickpea (q/ha)		Chickpea-equivalent yield (q/ha)	Net return (Rs/ha)	Benefit : cost ratio
								Grain	Stover	Grain	Straw			
Nitrogen management (kg NPK/ha)														
20:40:40	45.0	21.7	19.6	20.7	1.5	41.4	16.2	38.3	58.1	20.0	32.3	37.2	27,141	1.9
30:60:40	50.0	26.0	23.8	15.4	1.3	47.3	18.5	42.3	62.5	23.1	37.2	42.2	33,497	2.1
Tillage practice														
Normal ploughing	45.8	20.2	19.5	15.7	1.2	41.1	15.3	39.1	59.0	20.1	33.1	37.7	29,640	2.1
Deep ploughing with spade (23 cm deep)	49.2	27.6	23.9	20.3	1.5	47.6	19.3	41.5	61.7	23.1	36.4	41.8	34,272	2.2
Irrigation level														
CPE of 60 mm	49.1	29.4	23.2	17.2	1.3	47.4	18.8	41.7	61.6	24.3	37.2	43.1	37,091	2.3
CPE of 80 mm	45.9	18.3	19.9	18.8	1.5	41.4	15.9	38.9	58.5	18.8	32.3	36.3	27,185	2.0
CD (P=0.05)	3.1	2.0	2.6	1.6	0.2	3.1	2.1	3.6	4.0	1.1	1.4	3.1		

Table 2. Physical properties of the soil as influenced by different treatments in rice-chickpea cropping system

Treatment	**Bulk density (g/cc)**	**Water holding capacity (%)**	**Particle density (g/cc)**	**Pore space (%)**	**Volume of expansion (%)**
Nutrient management (kg NPK/ha)					
20:40:40	1.50	36.0	2.23	45.0	11.5
30:60:40	1.49	35.3	2.22	47.6	14.0
Tillage practice					
Normal ploughing	1.51	35.3	2.23	44.7	11.0

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Deep ploughing with spade (23 cm deep)	1.48	36.0	2.22	48.0	14.6
Irrigation level					
CPE of 60 mm	1.50	36.3	2.23	46.8	13.6
CPE of 80 mm	1.49	35.0	2.22	45.8	12.0
Initial	1.53	33.8	2.24	40.1	10.5

The soil moisture-depletion pattern showed that the maximum depletion was recorded from 15-30 cm soil layer in both the irrigation levels followed by 0-15, 30-45, 45-60 and 75-90 cm layers. More moisture was depleted in case of 2 irrigations given at CPE of 80 mm as compared to 60 mm during both the years. The contribution made from 0-15, 15-30 and 30-45 cm soil depths in CPE of 80 mm was 25.9, 27.5 and 17.3% in 1999-2000 and 27.8, 29.6 and 19.5% in 2000-2001 respectively. It was observed that 2 and 1 irrigations given at CPE of 80 mm showed higher water-use efficiency (13.91 and 8.62 kg/ ha-mm) compared to CPE of 60 mm during 1999-2000 and 2000-2001 respectively (Table 3). Sharma *et al.* found that number and dry weight of root nodules and water-use efficiency consistently decreased by irrigations applied at IW: CPE of 0.6 than no irrigation [6].

A significant increase in the uptake levels of nitrogen, phosphorus and potassium by rice and chickpea was found in case of in CPE ratio of 60 mm compared to that of 80 mm (Table 4). Significantly higher total nitrogen, phosphorus and potassium uptake by the system was recorded in CPE of 60 mm than CPE of 80 mm. Similar trend was also obtained in respect P and K content in rice and chickpea with CPE of 60 mm. On the other hand, there was a significant increase in the nitrogen content in rice and chickpea, in the case CPE of 80 mm compared to than CPE of 60 mm.

Table 3. Water-use efficiency of chickpea as influenced by irrigation levels

Irrigation levels	No. of irrigation	Irrigation requirement (mm)	Effective rainfall (mm)	Water requirement (mm)	Consumptive use (mm)	Water use
1999-2000						
CPE of 80 mm	2	142.8		142.8	165.2	13.92
CPE of 60 mm	3	214.2		214.2	244.9	11.44
2000-2001						
CPE of 80 mm	1	143.2	52	195.1	170.1	8.62
CPE of 60 mm	2	216.4	52	268.4	253.5	8.13

Table 4. Uptake of N, P and K by rice and chickpea and total uptake by cropping system as influenced by different treatments in rice-chickpea cropping system

I. Treatment	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Rice	**Chickpea**	**Total**	**Rice**	**Chickpea**	**Total**	**Rice**	**Chickpea**	**Total**
Nutrient management (kg NPK/ha)									
20:40:40	74.3	73.7	148.0	8.4	7.0	15.4	58.6	24.0	82.6
30:60:40	78.6	81.4	160.0	10.6	9.5	20.0	71.0	29.6	100.6
Tillage practice									
Normal ploughing	71.5	69.8	141.3	8.2	6.8	15.0	58.6	23.8	80.4
Deep ploughing with spade (23 cm deep)	81.8	85.9	167.7	10.8	9.7	20.5	71.0	29.8	100.8
Irrigation level									
CPE of 60 mm	78.3	86.5	164.8	10.4	9.7	20.1	68.9	30.6	99.5
CPE of 80 mm	74.6	68.5	143.2	8.6	6.8	15.3	60.7	23.0	83.7

CD (P=0.05)	3.6	3.7	7.1	1.5	1.2	5.7	4.5	2.4	6.1

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