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Research Paper

Effect of nitrogen management on wheat-fodder cowpea crop sequence

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ABSTRACT

The present study investigated the effect of nitrogen management on wheat-fodder cowpea crop sequence. Significantly higher wheat grain equivalent yield (9351 kg/ha) was recorded with the treatment combination of 75% RDN through chemical fertilizer + 25% RDN through vermicompost to wheat and 100% RDN to fodder cowpea (N_2L_3), which remained at par with the treatment combination of N_3L_2. At the same time, the highest net return (₹134939/ha) and benefit-cost ratio (BCR) (2.86) of wheat-fodder cowpea crop sequence were secured with the application of a recommended dose of fertilizer (RDF) (120-60-00, NPK kg/ha + 25 kg/ha $ZnSO_4$) to wheat and 100% of RDN to fodder cowpea (N_1L_3), which remained at par with the treatment combination of 75% RDN through chemical fertilizer + 25% RDN through FYM to wheat and 100% of RDN to fodder cowpea (N_3L_2).

Key words: BCR, Cropping sequence, Nitrogen management, System Profitability, System Productivity, WGEY

INTRODUCTION

Wheat has been described as "king of cereal" and one of the most important staple food crops of the world. Wheat straw is utilized as fodder for feeding the livestock. Livestock is an important component in our agricultural production system, which plays a vital role in the national economy of the country. However, a huge shortage of feed, which is an acute problem in livestock production in India, can be overcome by cultivating some potential forage. Among the forages, legumes are important in supplying the most demanding and quality nutrients like protein, minerals, and vitamins to the animals. Legumes are noteworthy in that most of them have symbiotic nitrogen-fixing bacteria in structures called root nodules (Sanginga *et al.* 1996). Cowpea is quickly growing and excellent in forage quality. Being rich in protein and containing many other nutrients, cowpea is known as vegetable meat. In recent years, due to the unsuitable effect of chemical fertilizers on the soil, the use of organic materials serves as a suitable source to supply soil food elements. Judicious use of FYM with chemical fertilizers improves soil's physical, chemical, and biological properties and improves crop productivity (Sharma *et al.* 2007). Balanced use of nitrogen is a key point for higher land profitability and a healthy environment. Nitrogen is one of the major essential nutrients applied to the crop for higher vegetative growth, productivity, and quality (Iqbal *et al*. 2012). Due to intensive cropping, where food grain production and fertilizer use run parallel, the soil is degrading day by day to soil fertility and productivity. Since agriculture has become more intensive and chemical-dependent, therefore soil toxicity and nutrient imbalance threaten sustainable production. So, we have to think about cheap and easily available alternate sources of nutrients, which not only supply the nutrients to the soil but also improve the physico-chemical properties and biological conditions of the soil. Thus, demand for inputs can be lowered by recycling the available farm resources and residues through the cropping sequence. Cropping sequence is a rotation system approach in crop production that focuses on the available natural resources to be preserved and utilized more efficiently. It involves the growing of succession crops on one field at a particular time. Keeping this view in mind, the field experiment was conducted to study the effect of nitrogen management on wheat-fodder cowpea crop sequence.

MATERIALS AND METHODS

Experimental site and growing conditions

The field experiment was laid out on a fixed site of plot number C-13 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural

University, Sardarkrushinagar, Banaskantha (Gujarat) during *Rabi* and summer season (2020-21 and 2021-22). Sardarkrushinagar is situated at 24°19′ North latitude and 72°19′ East longitude with an elevation of 154.42 m above the mean sea level. The soil of the experimental plot was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus, and high in available potassium status. EC was very low, showing that the soil was free from salinity hazards. It is evident from the meteorological data of *Rabi* and summer season that the mean maximum temperature varies from 22.9 to 43 °C and 21.9 to 43.1 °C and the mean minimum temperature ranges from 6.7 to 26.4 °C and 6.0 to 25.4 °C during 2020-21 and 2021-22, respectively. The mean morning relative humidity ranged from 52 to 81% and 57 to 80.3%. However, in the evening, it ranged from 16 to 56% and 20 to 56.9% during the period of experimentation in corresponding years. The mean wind velocity ranged from 2 to 10 km/h and 2.3 to 11.5 km/h. The mean potential evaporation ranged from 2.7 to 8.1 mm and 3.3 to 12.3 mm, and mean bright sunshine hours varied from 6.7 to 11.1 hrs/day and 4.1 to 10.7 hrs/day during both years, respectively.

Experimental details

The treatments consisted of nitrogen management *viz*., N1: RDF (120-60-00, NPK kg/ha + 25 kg/ha ZnSO4), N2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost, N3: 75% RDN through chemical fertilizer + 25% RDN through FYM, N4: 75% RDN through chemical fertilizer + 12. 5% RDN through vermicompost + 12.5% RDN through FYM, N5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost, N6: 50% RDN through chemical fertilizer + 50% RDN through FYM and N7: 50% RDN through chemical fertilizer + 25% RDN through vermicompost + 25% RDN through FYM to wheat in *Rabi* season as main plot treatments and replicated three times in Randomized Block Design. During the summer season, each main plot treatment was split into three subplot treatments with three levels of nitrogen viz., L1: Control, L2: 75% of RDN, and L3: 100% of RDN to fodder cowpea resulting in twenty-one treatment combinations replicated three times in Split Plot Design. According to the content of nutrients, different organic manures were applied to wheat crops as per treatments 10 days before sowing and uniformly mixed with soil. The wheat crop variety GW 451 was treated with *Azotobacter* biofertilizer @ 10 ml/kg seed during both years with 22.5 cm row spacing and a seed rate of 125 kg/ha. Fodder cowpea variety EC 4216 was treated with *Rhizobium* biofertilizer @ 10 ml/kg seed during both years with 30 cm row spacing and a seed rate of 40 kg/ha.

The wheat grain equivalent yield (WGEY) was computed as:

$$\text{WGEY (kg/ha)} = \frac{(Ywg \times Pwg) + (Yws \times Pws) + (Yfc \times Pfc)}{Pwg}$$

Where,

WGEY = Wheat grain equivalent yield

Ywg = Yield of wheat grain

Pwg = Market rate of wheat grain

Yws = Yield of wheat straw

Pws = Market rate of wheat straw

Yfc = Yield of green fodder cowpea

Pfc = Market rate of fodder cowpea

The system productivity, system profitability and benefit cost ratio were computed as:

$$\text{System productivity} = \frac{\text{Wheat grain equivalent yield}}{\text{Wheat-fodder cowpea crop sequence duration}}$$

$$\text{System profitability} = \frac{\text{Gross return from crop sequence}}{\text{Wheat-fodder cowpea crop sequence duration}}$$

$$\text{Benefit-cost ratio (BCR) (₹/ha)} = \frac{\text{Gross returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Statistical analyses

The data on various variables were analyzed by using statistical procedures as described by Panse and Sukhatme (1967). The simple technique of analysis of variance may not be valid under two different seasonal conditions as the error variances in the seasons and the treatment × season interaction may be significant. Hence, pooled analysis of the preceding wheat and succeeding fodder cowpea crop analyzed for two years was worked out as per the method described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Wheat grain equivalent yield

Effect of nitrogen management

Application of 75% RDN through chemical

fertilizer + 25% RDN through FYM (N_3) to wheat crop recorded significantly higher wheat grain equivalent yield (8720, 8797 and 8759 kg/ha) during both the years and in pooled study, respectively and remained statistically at par with the treatment N_1 (8669, 8747 and 8708 kg/ha), N_2 (8562, 8644 and 8603 kg/ha) and N_4 (8433, 8590 and 8511 kg/ha). Treatment N_5 (7952 and 8050 kg/ha) also remained at par during both years. However, significantly lower wheat grain equivalent yield (7605, 7731, and 7668 kg/ha) was recorded with the application of 50% RDN through chemical fertilizer + 50% RDN through FYM (N_6) during both the years and in pooled studies, respectively. The percent increase in wheat grain equivalent yield under N_3, N_1, N_2, and N_4 were 14.23, 13.56, 12.20, and 11.00% over N_6 in the pooled study, respectively. Application of adequate amounts of nutrients through organic and inorganic sources might have improved soil fertility, which resulted in higher growth, yield attributes, yields, and wheat grain equivalent yield. These results are in line with the findings of Nag (2006) in the wheat-fodder cowpea cropping sequence, Dubey (2014) in rice-berseem cropping sequence, Mansuri (2016) in rice-chickpea cropping sequence, Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence and Patel *et. al.* (2024) in grain amaranth-fodder maize cropping sequence.

Effect of levels of nitrogen

Significantly higher wheat grain equivalent yield was recorded when fodder cowpea received 100% of RDN (L_3, 8672, 8759, and 8716 kg/ha)) during both the years and in the pooled study, respectively, and remained at par with level L_2 (8619, 8706, and 8663 kg/ha). However, significantly lower wheat grain equivalent yield was recorded with the treatment control (7442, 7563, and 7502 kg/ha) during both the years and in pooled study, respectively. The percent increase in wheat grain equivalent yield under L_3 and L_2 was 16.17 and 15.47% over L_1 in the pooled study, respectively. An adequate supply of nitrogen improved growth and yield attributes as well as yields of fodder cowpea, which resulted in higher wheat grain equivalent yield. These results are in line with the findings of Mansuri (2016) in the rice-chickpea cropping sequence , Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence and Patel *et. al.* (2024) in grain amaranth-fodder maize cropping sequence..

Interaction effect

During the first year of the experiment, it can be observed that the treatment combination of N_2L_3 recorded a significantly higher wheat grain equivalent yield of 9434 kg/ha, which remained at par with the treatment combination of N_3L_2 (9275 kg/ha), N_1L_3 (9181 kg/ha), N_3L_3 (9178 kg/ha) and N_1L_2 (9083 kg/ha). Significantly lower wheat grain equivalent yield was recorded under the treatment combination N_6L_1 (6845 kg/ha). In the second year of the experiment, it can be observed that a significantly higher wheat grain equivalent yield was registered under the treatment combination of N_3L_3 (9454 kg/ha), which remained at par with the treatment combination of N_1L_3 (9391 kg/ha), N_2L_3 (9268kg/ha), N_1L_2 (9201 kg/ha) and N_4L_3 (9017 kg/ha. Significantly lower wheat grain equivalent yield was recorded under the treatment combination of N_7L_1 (7038 kg/ha). In pooled results, wheat grain equivalent yield was recorded significantly higher under the treatment combination of N_2L_3 (9351 kg/ha), which remained at par with the treatment combination of N_3L_3 (9316 kg/ha), N_1L_3 (9286 kg/ha), N_1L_2 (9142 kg/ha) and N_3L_2 (9072 kg/ha). Significantly lower wheat grain equivalent yield was registered under the treatment combination of N_7L_1 (6965 kg/ha). The cumulative effect on preceding wheat with the integration of inorganic sources along with organic sources, *i.e.* FYM, vermicompost, and direct application of nitrogen to fodder cowpea, might have increased the yield of crops, leading to increased wheat grain equivalent yield. These results are in accordance with the findings of Mansuri (2016) in the rice-chickpea cropping sequence, Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence and Patel *et. al.* (2024) in grain amaranth-fodder maize cropping sequence.

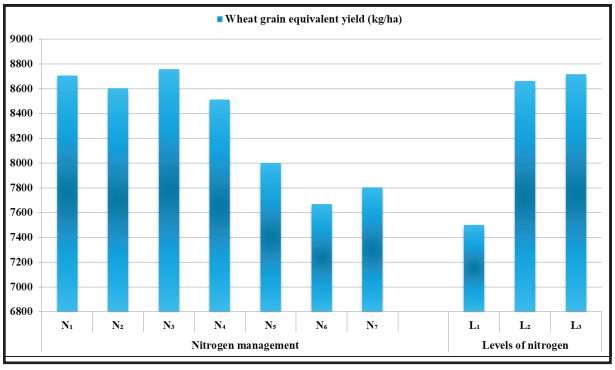

Fig. 1. Wheat grain equivalent yield as influenced by nitrogen management (Pooled over two years)

Table 1. Wheat grain equivalent yield as influenced by nitrogen management.

Treatments	Wheat grain equivalent yield (kg/ha)		
	2020-21	2021-22	Pooled
Main plot: Nitrogen management in wheat			
N_1: RDF (120-60-00, NPK kg/ha + 25 kg/ha $ZnSO_4$)	8669	8747	8708
N_2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost	8562	8644	8603
N_3: 75% RDN through chemical fertilizer + 25% RDN through FYM	8720	8797	8759
N_4: 75% RDN through chemical fertilizer + 12.5% RDN through vermicompost + 12.5% RDN through FYM	8433	8590	8511
N_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	7952	8050	8001
N_6: 50% RDN through chemical fertilizer + 50% RDN through FYM	7605	7731	7668
N_7: 50% RDN through chemical fertilizer + 25% RDN through vermicompost + 25% RDN through FYM	7768	7839	7803
S. Em. ±	260.6	258.3	183.4
C. D. (P=0.05)	803	796	535
C. V. %	9.48	9.29	9.38
Sub plot: Levels of nitrogen in fodder cowpea			
L_1**:** Control	7442	7563	7502
L_2: 75% of RDN	8619	8706	8663
L_3: 100% of RDN	8672	8759	8716
S. Em. ±	67.7	59.1	44.9
C. D. (P=0.05)	196	171	127
Interaction (N × L)			
S. Em. ±	179.2	156.2	118.9
C. D. (P=0.05)	519	453	337
Interactions	Y × N, Y × L and Y × N × L		NS
C. V. %	3.76	3.24	3.51

Table 2. Interaction effect on wheat grain equivalent yield during 2020-21, 2021-22 and pooled study

	Wheat grain equivalent yield (kg/ha)											
	2020-21				2021-22				Pooled study			
N x L	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
N_1	7742	9083	9181	8669	7650	9201	9391	8747	7696	9142	9286	8708
N_2	7654	8599	9434	8562	7850	8814	9268	8644	7752	8707	9351	8603
N_3	7707	9275	9178	8720	8071	8868	9454	8797	7889	9072	9316	8759
N_4	7994	8394	8910	8433	7907	8846	9017	8590	7951	8620	8964	8511
N_5	7259	8582	8016	7952	7321	8585	8246	8050	7290	8583	8131	8001
N_6	6845	8068	7903	7605	7104	8377	7711	7731	6974	8222	7807	7668
N_7	6891	8332	8081	7768	7038	8250	8228	7839	6965	8291	8154	7803
Mean	7442	8619	8672		7563	8706	8759		7502	8663	8716	
S. Em. ±	179.2				156.2				118.9			
C. D. (P=0.05)	519				453				337			

System productivity

Effect of nitrogen management

From the presented data in the Table 3, it could be seen that the maximum wheat-fodder cowpea system productivity (46.38, 46.06, and 46.22 kg/ha/day) was recorded with application of 75% RDN through chemical fertilizer + 25% RDN through FYM (N_3) to wheat crop followed by N_1 (46.11, 45.80 and 45.95 kg/ha/day) during both the years and in pooled study, respectively. The minimum system productivity (40.45, 40.47, and 40.46 kg/ha/day) was noted under the application of 50% RDN through chemical fertilizer + 50% RDN through FYM (N_6) to wheat during both the years and in the pooled study, respectively. The results are in accordance with those reported by Dixit *et al.* (2015) in chickpea-fodder sorghum cropping sequence.

Effect of levels of nitrogen

The maximum system productivity was recorded under the application of 100% of RDN

(L_3, 46.13, 45.86 and 45.99 kg/ha/day) to fodder cowpea followed by L_2 (45.85, 45.58 and 45.71 kg/ha/day) during both the years and in pooled study, respectively. The minimum system productivity was recorded with L_1 (39.58, 39.60 and 39.59 kg/ha/day) during both the years and in pooled study, respectively. (Table 3)The results are in accordance with those reported by Dixit *et al.* (2015) in chickpea-fodder sorghum cropping sequence.

System profitability

Effect of nitrogen management

From the presented data in the Table 3, it could be seen that the maximum wheat-fodder cowpea system profitability was recorded with the application of 75% RDN through chemical fertilizer + 25% RDN through FYM (1020, 1046 and 1033 ₹/ha/day) to wheat crop followed by N_1 (1014, 1040 and 1027 ₹/ha/day) during both the years and in pooled study, respectively. The minimum system profitability was noted under the application of 50% RDN through chemical fertilizer + 50% RDN through FYM (N_6, 890, 919 and 904 ₹/ha/day)) to wheat during both the years and in pooled study, respectively. The results are in accordance with those reported by Dixit *et al.* (2015) in chickpea-fodder sorghum cropping sequence.

Effect of levels of nitrogen

The maximum system profitability was recorded under the application of 100% of RDN (L_3, 1015, 1041, and 1028 ₹/ha/day) to fodder cowpea followed by L_2 (1009, 1035 and 1022 ₹/ha/day) during both the years and in pooled study, respectively. The minimum system profitability was recorded with L_1 (871, 899 and 885 ₹/ha/day) during both the years and in the pooled study, respectively. (Table 3) The results are in accordance with those reported by Dixit *et al.* (2015) in chickpea-fodder sorghum cropping sequence.

Economics of cropping sequence

Effect of nitrogen management

Data in Table 4 showed that the highest net returns of ₹122131/ha with BCR of 2.68 were attained by the treatment of RDF (120-60-00, NPK kg/ha + 25 kg/ha $ZnSO_4$) (N_1) to wheat, which was followed by treatment N_3 with net returns of ₹119436/ha with BCR of 2.56. Application of 50% RDN through chemical fertilizer + 50% RDN through vermicompost (N_5) resulted in the lowest net returns of ₹81967/ha with BCR of 1.85. The results were in accordance with those reported by Nag (2006) in the wheat-fodder cowpea cropping sequence, Dubey (2014) in the rice-berseem cropping sequence, and Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence.

Effect of levels of nitrogen

Data in Table 4 further revealed that the fodder cowpea fertilized with 100% of RDN (L_3) secured highest net returns of ₹111618/ha with BCR of 2.34, which was followed by 75% of RDN (L_2) with net returns of ₹110500/ha and BCR of 2.33. The

Table 3. Wheat-fodder cowpea system productivity and profitability as influenced by nitrogen management

Treatments	System productivity (kg/ha/day)			System profitability (₹/ha/day)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Main plot: Nitrogen management in wheat						
N_1: RDF (120-60-00, NPK kg/ha + 25 kg/ha $ZnSO_4$)	46.11	45.80	45.95	1014	1040	1027
N_2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost	45.54	45.26	45.40	1002	1027	1015
N_3: 75% RDN through chemical fertilizer + 25% RDN through FYM	46.38	46.06	46.22	1020	1046	1033
N_4: 75% RDN through chemical fertilizer + 12.5% RDN through vermicompost + 12.5% RDN through FYM	44.86	44.97	44.91	987	1021	1004
N_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	42.30	42.15	42.22	931	957	944
N_6: 50% RDN through chemical fertilizer + 50% RDN through FYM	40.45	40.47	40.46	890	919	904
N_7: 50% RDN through chemical fertilizer + 25% RDN through vermicompost + 25% RDN through FYM	41.32	41.04	41.18	909	932	920
Sub plot: Levels of nitrogen in fodder cowpea						
L_1: Control	39.58	39.60	39.59	871	899	885
L_2: 75% RDN	45.85	45.58	45.71	1009	1035	1022
L_3: 100% RDN	46.13	45.86	45.99	1015	1041	1028

lowest net returns of ₹84749/ha and BCR of 2.02 were recorded with treatment control (L_1) to fodder cowpea. The results are in accordance with those reported by Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence.

Interaction effect

Results in Table 5 revealed that highest net returns of ₹134939/ha with BCR of 2.86 were secured under treatment combination of RDF (120-60-00, NPK kg/ha + 25 kg/ha $ZnSO_4$) to wheat and 100% of RDN to fodder cowpea (N_1L_3), which was followed by the treatment combination N_1L_2 (₹131787/ha net returns and 2.82 BCR), N_3L_3 (₹131775/ha net returns and 2.72 BCR) and N_3L_2 (₹126387/ha net returns and 2.65 BCR). The lowest net returns of ₹66231/ha and BCR of 1.68 were observed under the treatment combination 50% RDN through chemical fertilizer

Table 4. Economics of wheat-fodder cowpea sequence as influenced by nitrogen management (Average of 2020-21 and 2021-22)

Treatments	Gross returns (₹/ha)			Cost of cultivation (₹/ha)			Net returns (₹/ha)	BCR
	WGEY (kg/ha)	Price of wheat grain (₹/kg)	Total	Wheat	Fodder cowpea	Sequence		
Main plot: Nitrogen management in wheat								
N_1	8708	22.35	194624	44669	27824	72493	122131	2.68
N_2	8603	22.35	192277	56690	27824	84514	107763	2.28
N_3	8759	22.35	195764	48504	27824	76328	119436	2.56
N_4	8511	22.35	190221	52848	27824	80672	109549	2.36
N_5	8001	22.35	178822	69031	27824	96855	81967	1.85
N_6	7668	22.35	171380	53833	27824	81657	89723	2.10
N_7	7803	22.35	174397	61179	27824	89003	85394	1.96
Sub plot: Levels of nitrogen in fodder cowpea								
L_1	7502	22.35	167670	55251	27670	82921	84749	2.02
L_2	8663	22.35	193618	55251	27868	83119	110500	2.33
L_3	8716	22.35	194803	55251	27934	83185	111618	2.34

Table 5. Economics of wheat-fodder cowpea sequence as influenced by different treatment combinations of main and subplot treatments (Average over 2020-21 and 2021-22).

Treatment combinations	Gross returns (₹/ha)			Cost of cultivation (₹/ha)			Net returns (₹/ha)	BCR
	WGEY (kg/ha)	Price of wheat grain (₹/kg)	Total	Wheat	Fodder cowpea	Sequence		
N_1L_1	7696	22.35	172006	44669	27670	72339	99667	2.38
N_1L_2	9142	22.35	204324	44669	27868	72537	131787	2.82
N_1L_3	9286	22.35	207542	44669	27934	72603	134939	2.86
N_2L_1	7752	22.35	173257	56690	27670	84360	88897	2.05
N_2L_2	8707	22.35	194601	56690	27868	84558	110043	2.30
N_2L_3	9351	22.35	208995	56690	27934	84624	124371	2.47
N_3L_1	7889	22.35	176319	48504	27670	76174	100145	2.31
N_3L_2	9072	22.35	202759	48504	27868	76372	126387	2.65
N_3L_3	9316	22.35	208213	48504	27934	76438	131775	2.72
N_4L_1	7951	22.35	177705	52848	27670	80518	97187	2.21
N_4L_2	8620	22.35	192657	52848	27868	80716	111941	2.39
N_4L_3	8964	22.35	200345	52848	27934	80782	119563	2.48
N_5L_1	7290	22.35	162932	69031	27670	96701	66231	1.68
N_5L_2	8583	22.35	191830	69031	27868	96899	94931	1.98
N_5L_3	8131	22.35	181728	69031	27934	96965	84763	1.87
N_6L_1	6974	22.35	155869	53833	27670	81503	74366	1.91
N_6L_2	8222	22.35	183762	53833	27868	81701	102061	2.25
N_6L_3	7807	22.35	174486	53833	27934	81767	92720	2.13
N_7L_1	6965	22.35	155668	61179	27670	88849	66819	1.75
N_7L_2	8291	22.35	185304	61179	27868	89047	96257	2.08
N_7L_3	92524	89730	182254	61179	27934	89113	93141	2.05

+ 50% RDN through vermicompost to wheat and control to fodder cowpea (N_5L_1). The results are in accordance with Jangir *et al.* (2021) in grain amaranth-cowpea cropping sequence and Patel *et. al*. (2024) in grain amaranth-fodder maize cropping sequence.

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