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Effect of integrated nitrogen management on wheat-green gram crop sequence

Dr. MB Khadadiya, Dr. LJ Desai and Dr. SS Desai

Abstract
A field experiment was conducted during the *rabi* and summer seasons of 2020-21 and 2021-22 at C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, S. K. Nagar, Gujarat, India to study on integrated nitrogen management in wheat and its residual effect on summer green gram under North Gujarat condition. There were six integrated nitrogen management treatments to wheat and eighteen treatment combinations comprising residual effect of preceding six integrated nitrogen management treatments of wheat followed by three levels of recommended dose of nitrogen to green gram. Pooled results over 2 years indicated that, application of 50% RDN through inorganic source + 50% RDN through organic source to wheat resulted in significantly higher wheat grain equivalent yield (7745 kg/ha), higher system productivity (39.61 kg/ha/day) and system profitability (899 ₹/ha/day). Whereas direct application of 100% recommended dose of nitrogen to green gram, recorded significantly higher wheat grain equivalent yield (7288 kg/ha), higher system productivity (37.27 kg/ha/day) and system profitability (846 ₹/ha/day) of crop sequence. In economics of wheat-green gram crop sequence were recorded higher net return (98268 ₹/ha) and BCR (2.36) with the application of 50% RDN through inorganic source + 50% RDN through organic source to wheat' whereas in case of levels of nitrogen 100% RDN recorded highest net return (74720 ₹/ha) and BCR (1.82) of wheat-green gram crop sequence.

Keywords: Wheat grain equivalent yield, System productivity, system profitability, net return and benefit cost ratio (BCR), recommended dose of nitrogen (RDN)

Introduction
Wheat is one of the most important crop of India not only in terms of acreage, but also in terms of its versatility for adoption under wide range of agro climatic conditions and crop growing situations. Wheat has its own outstanding importance as a human food; it is rich in carbohydrates and protein. About 35 per cent of the world's population directly or indirectly depends upon wheat for food and providing 20% of humanity's dietary energy supply and serving as the main source of protein in developing Nations (Braun *et al.*, 2010) [1]. Green gram (*Vigna radiate* L.) is one of the important pulse crop in India and cultivated since ancient times. The biological value improves greatly, when wheat or rice is combined with green gram because of the complementary relationship of the essential amino acids. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc. In addition to being an important source of human food and animal feed, plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. Green gram, in contrast with green manures, provide grain to augment income and protein as well as reduce the use of mineral nitrogen in wheat-based cropping systems.
Experience from long term fertilizers experiments revealed that integrated use of farm yard manures, vermicompost, biocompost etc. with graded levels of chemical fertilizers is promising not only in maintaining higher productivity but also in providing maximum stability in crop production. The response of N as chemical fertilizer generally increases when it is used in combination with compost, FYM, vermicompost, etc. can save N fertilizer. Application of organic materials along with inorganic fertilizers into the soil leads to increase in productivity of the system and also sustained the soil health for longer period.
In this background, a field experiment was conducted to study the performance of wheat-green gram crop sequence and to identify the best feasible integrated nitrogen management practice to increase the production potential of wheat-green gram cropping sequence.

Material and Methods

A field experiment was conducted during *rabi* and summer season of 2020-21 and 2021-22 at plot number C-13 (24º19' N and 72 º 19' E, 154.42 m altitude), Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). The site of experiments for both the years remains same. The soil was loamy sand, low in organic carbon (0.15%) and available nitrogen (145 kg/ha), medium in available phosphorus (36.5 kg/ha) and high in available potassium (267.5 kg/ha) status. EC was very low (0.09 dS/m) showing that the soil was free from salinity hazard. Month wise maximum temperature varies from 22.9 to 43 ºC and 21.9 to 43.1 ºC and minimum temperature ranged between 6.7 to 35.2 ºC and 6.0 to 25.4 ºC during 2020-21 and 2021-22, respectively. The morning relative humidity ranged between 52 to 81% and 57 to 80.3%. However, at evening, it ranged between 16 to 56% and 20 to 56.9% during the period of experimentation in corresponding years. The wind velocity ranged between 2 to 10 km/hr and 2.3 to 11.5 km/hr. The potential evaporation range between 2.7 to 8.1 mm and 3.3 to 12.3 mm and bright sunshine hours varies from 6.7 to 11.1 and 4.1 to 10.7 hrs/day during both the years, respectively.

There were six integrated nitrogen management treatments *viz.* N_1-100% RDN through organic source, N_2-75% RDN through organic source + two spray of *panchgavya* @ 2% at 30 and 60 DAS, N_3-100% RDN through inorganic source, 75% RDN through inorganic source + 25% RDN through organic source, N_5-50% RDN through inorganic source + 50% RDN through organic source, N_6-25% RDN through inorganic source + 75% RDN through organic source to wheat (organic source was applied @ 1/3 nitrogen from each of FYM, vermicompost and castor cake before 10 days of sowing, RDF of wheat: 120-60-00 kg N-P-K/ha) during *rabi* season were laid out in randomized block design (gross plot: 11.0 m × 3.6 m and net plot: 10.0 m × 2.7 m) and eighteen treatment combinations comprising residual effect of preceding six integrated nitrogen management treatments of wheat followed by three levels of RDN *viz.* 50, 75 and 100% RDN to green gram in spilt plot design (gross plot: 3.0 m × 3.6 m, net plot: 2.0 m × 2.7 m and RDF of green gram: 20-40-00 kg N-P-K/ha) with four replications. There is non-significant interaction effect was found between treatments and years. The half dose of nitrogen in form of urea was manually applied before sowing of wheat crop as per treatments. The remaining half dose of nitrogen was applied in the form of urea at CRI stage after 1st irrigation to each plot as per treatment. In green gram crop full dose of nitrogen in form of urea was manually applied before sowing as per treatments. The phosphorus was applied common to all treatments as per recommended dose of fertilizer in both the crop. Nutrients composition of FYM (0.43, 0.17, 0.44% and 0.45, 0.18 and 0.45% NPK), vermicompost (1.20, 0.89, 1.13% and 1.40, 0.87, 1.12% NPK), cator cake (6.10, 2.40, 1.00% and 6.30, 2.50, 1.10% NPK) and *Panchgavya* (0.021, 0.019, 0.022% and 0.023, 0.020, 0.023% NPK) during 2020-21 and 2021-22, respectively. According to content of nutrient, different organic manures were applied to wheat crop as per treatments at least 10 days before of sowing and uniformly mixed with soil. Before sowing seeds were treated with *Azotobacter* biofertilizer @ 10 ml/kg seed during both the years. Before sowing seeds were treated with *Azotobacter* biofertilizer @ 10 ml/kg seed during both the years for wheat *var.* GW-451 (Gujrat Wheat), whereas green gram seeds *var.* GM-4 (Gujarat Mungbean) were treated with *Rhizobium* biofertilizer @ 10 ml/kg seed during both the years. Wheat crop was sown at 22.5 cm (row to row) spacing by using uniform seed rate of 125 kg/ha and green gram crop was sown at 45 cm (row to row) spacing by using uniform seed rate of 17.5 kg/ha.

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

$$\text{WEY (kg/ha)} = \frac{(Ywg \times Pwg) + (Yws \times Pws) + (Ygs \times Pgs) + (Ygh \times Pgh)}{Pwg}$$

Where,
WEY = 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
Ygs = Yield of green gram seed
Pgs = Market rate of green gram seed
Ygh = Yield of green gram stover
Pgh = Market rate of green gram stover

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

$$\text{System productivity (kg/ha/day)} = \frac{\text{Wheat grain equivalent yield}}{\text{Wheat-green gram sequence duration}}$$

$$\text{System profitability (₹/ha/day)} = \frac{\text{Gross returns from crop sequence}}{\text{Wheat-green gram sequence duration}}$$

$$\text{BCR (₹/ha)} = \frac{\text{Gross realization (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

The data on various variables were analysed by using statistical procedures as described by Panse and Sukhatme (1967) [9]. 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 x season interaction may be significant. Hence, pooled analysis of the preceding wheat and succeeding green gram crop analyzed for two years was worked out as per the method described by Panse and Sukhatme (1967) [9].

Results and Discussion

Performance of wheat-green gram cropping sequence

Wheat grain equivalent yield

Effect of integrated nitrogen management

Application of 50% RDN through inorganic source + 50% RDN through organic source (N_5) to wheat crop recorded significantly the higher wheat grain equivalent yield (7604, 7885 and 7745 kg/ha) during both the year of experiment and in pooled analysis, respectively, which remain statistically at par with treatment N_3 (7395 and 7603 kg/ha), N_4 (7346 and 7573 kg/ha) and N_6 (6807 and 7071 kg/ha) during 2020-21 and 2021-22, whereas in pooled analysis it was at par with treatment N_3 (7499 kg/ha) and N_4 (7459 kg/ha). Application of adequate amount of nutrients through organic and inorganic source improved soil fertility might have increased growth and yield attributes of wheat and green gram, which resulted in higher grain and straw yields of wheat as well as seed and stover yield of summer green gram crop consequently higher grain wheat equivalent yield. These results are in line with the findings of Lakshmi *et al.* (2012)

[12], Mondal *et al.*, (2014) [8], Mahapatra *et al*. (2018) [5] and Patil *et al.* (2018) [10].

Effect of nitrogen levels

Wheat grain equivalent yield increased with increase in each level of nitrogen from 50 to 100% RDN. Significantly the higher wheat grain equivalent yield (7171, 7404 and 7288 kg/ha) were recorded when green gram received 100% RDN (L_3) during 2020-21, 2021-22 and in pooled results, respectively, which were at par with L_2: 75% RDN (7162, 7383 and 7272 kg/ha) during both the year of experiment and in pooled results, respectively. Adequate supply of nitrogen improved growth and yield attributes as well as seed and stover yields of green gram which resulted in higher wheat grain equivalent yield. These results are in line with the findings of Patil *et al.* (2018) [10].

Interaction effect

Significantly higher wheat grain equivalent yield (7922 and 8017 kg/ha) was obtained with treatment combination N_5L_2 (50% RDN through inorganic source + 50% RDN through organic source to wheat + 75% RDN to green gram) in first year of experiment and in pooled analysis, whereas in second year significantly higher wheat grain equivalent yield (8121 kg/ha) was obtained with treatment combination N_5L_3 (50% RDN through inorganic source + 50% RDN through organic source to wheat + 100% RDN to green gram). Treatment combination N_5L_2 (8111 kg/ha) in second year, N_5L_3 (7905 and 8013 kg/ha) in first year and in pooled analysis were statistically at par with the higher combination. The cumulative effect by preceding wheat with integration of inorganic source along with organic source *i.e*. FYM, castor cake, vermicompost and direct application of nitrogen to green gram might have increased the yield of crops so increased wheat equivalent yield. These results are in accordance with the finding of Jangir *et al.* (2021) [3], Patil *et al.* (2018) [10] and Mangaraj *et al*. (2021) [6].

System productivity and system profitability

Effect of integrated nitrogen management

Maximum wheat-green gram system productivity (39.20, 40.02 and 39.61 kg/ha/day) and profitability (₹890, ₹909 and ₹899/ha/day) was recorded with application of 50% RDN through inorganic source + 50% RDN through organic source to (N_5) to wheat crop followed by treatment N_3 during 2020-21, 2021-22 and in mean results, respectively.

Effect of nitrogen levels

Maximum system productivity (36.97, 37.58 and 37.27 kg/ha/day) and system profitability (₹839, ₹853 and ₹846/ha/day) was recorded with the application of 100% RDN (L_3) to summer green gram followed by L_2 (75% RDN) during both the year of experiment and in mean results, respectively. The results are in accordance with Mangaraj *et al*. (2021) [6].

Economics of cropping sequence

Effect of integrated nitrogen management

Highest net realization of ₹98,268 with BCR of 2.36 were attained by the treatment with 100% RDN through inorganic source (N_3) to wheat, which was followed by treatment 75% RDN through inorganic source + 50% RDN through organic source (N_4) with net returns of ₹88,719 with BCR of 2.10. The results were in accordance with those reported by Yadav *et al*. (2013) [11], Lakshmi *et al*. 2015 [12] and Gudadhe *et al.* 2020 [2].

Effect of nitrogen levels

Green gram crop fertilized with 100% RDN (L_3) secured highest net returns of ₹74,720/ha with BCR of 1.82, which was followed by 75% RDN (L_2) with net returns of ₹74,445/ha and BCR of 1.82.

Interaction effect

Results revealed that highest net realization of ₹1,01,834/ha with BCR of 2.41 was secured with treatment combination 100% RDN through inorganic source to wheat and 100% RDN to green gram (N_3L_3), which was followed by 100% RDN through inorganic source to wheat and 75% RDN to green gram (N_3L_2) with net returns of ₹1,01,673/ha and BCR of 2.41. The results are in accordance with Mansuri (2016) [7], Mangaraj *et al*. (2021) [6] Jangir *et al.* (2021) [3].

Table 1: Wheat grain equivalent yield as influenced by integrated nitrogen management

Treatment	Wheat grain equivalent yield (kg/ha)		
	2020-21	2021-22	Pooled
Main plot: Nitrogen management in wheat			
N_1: 100% RDN through organic source	6480	6600	6540
N_2: 75% RDN through organic source + two spray of panchgavya @ 2% at 30 and 60 DAS	6634	6825	6729
N_3: 100% RDN through inorganic source	7395	7603	7499
N_4: 75% RDN through inorganic source + 25% RDN through organic source	7346	7573	7459
N_5: 50% RDN through inorganic source + 50% RDN through organic source	7604	7885	7745
N_6: 25% RDN through inorganic source + 75% RDN through organic source	6807	7071	6939
S.Em.±	225.0	262.9	173.0
C.D. (P=0.05)	678	792	500
C.V.%	11.06	12.54	11.85
Sub plot: Levels of nitrogen in summer green gram			
L_1: 50% RDN	6800	6991	6895
L_2: 75% RDN	7162	7383	7272
L_3: 100% RDN	7171	7404	7288
S.Em.±	31.4	34.8	21.0
C.D. (P=0.05)	90	100	59
Interaction (N × L)			
S.Em.±	77.0	85.3	51.4
C.D. (P=0.05)	221	245	144
Interactions	Y × N, Y × L and Y × N × L		NS
C.V.%	2.19	2.35	2.03

Table 2: Interaction effect on wheat grain equivalent yield during 2020-21

N × L	Wheat grain equivalent yield (kg/ha)			
	L_1	L_2	L_3	Mean
N_1	6229	6644	6566	6480
N_2	6645	6574	6683	6634
N_3	7145	7471	7570	7395
N_4	7207	7487	7343	7346
N_5	6985	7922	7905	7604
N_6	6587	6874	6961	6807
Mean	6800	7162	7171	
S.Em.±	77.0			
C.D. (P=0.05)	221			

Table 3: Interaction effect on wheat grain equivalent yield during 2021-22

N × L	Wheat grain equivalent yield (kg/ha)			
	L_1	L_2	L_3	Mean
N_1	6377	6777	6645	6600
N_2	6773	6721	6980	6825
N_3	7231	7828	7749	7603
N_4	7242	7776	7699	7573
N_5	7422	8111	8121	7885
N_6	6900	7085	7228	7071
Mean	6991	7383	7404	
S.Em.±	85.3			
C.D. (P=0.05)	245			

Table 4: Interaction effect on wheat grain equivalent yield during pooled analysis

N × L	Wheat grain equivalent yield (kg/ha)			
	L_1	L_2	L_3	Mean
N_1	6303	6710	6606	6540
N_2	6709	6647	6832	6729
N_3	7188	7649	7660	7499
N_4	7225	7631	7521	7459
N_5	7204	8017	8013	7745
N_6	6743	6980	7094	6939
Mean	6895	7272	7288	
S.Em.±	51.4			
C.D. (P=0.05)	144			

Table 5: Wheat-summer green gram system productivity as influenced by integrated nitrogen management

Treatment	System productivity (kg/ha/day)		
	2020-21	2021-22	Pooled
Main plot: Nitrogen management in wheat			
N_1: 100% RDN through organic source	33.40	33.50	33.45
N_2: 75% RDN through organic source + two spray of panchgavya @ 2% at 30 and 60 DAS	34.20	34.64	34.42
N_3: 100% RDN through inorganic source	38.12	38.59	38.36
N_4: 75% RDN through inorganic source + 25% RDN through organic source	37.86	38.44	38.15
N_5: 50% RDN through inorganic source + 50% RDN through organic source	39.20	40.03	39.61
N_6: 25% RDN through inorganic source + 75% RDN through organic source	35.09	35.89	35.49
Sub plot: Levels of nitrogen in summer green gram			
L_1: 50% RDN	35.05	35.49	35.27
L_2: 75% RDN	36.92	37.48	37.20
L_3: 100% RDN	36.97	37.58	37.27

Table 6: Wheat-summer green gram system profitability as influenced by integrated nitrogen management

Treatment	System profitability (₹/ha/day)		
	2020-21	2021-22	Pooled
Main plot: Nitrogen management in wheat			
N_1: 100% RDN through organic source	758	760	759
N_2: 75% RDN through organic source + two spray of panchgavya @ 2% at 30 and 60 DAS	776	786	781
N_3: 100% RDN through inorganic source	865	876	871
N_4: 75% RDN through inorganic source + 25% RDN through organic source	860	873	866
N_5: 50% RDN through inorganic source + 50% RDN through organic source	890	909	899
N_6: 25% RDN through inorganic source + 75% RDN through organic source	796	815	806
Sub plot: Levels of nitrogen in summer green gram			
L_1: 50% RDN	796	806	801
L_2: 75% RDN	838	851	844
L_3: 100% RDN	839	853	846

Note: Wheat-green gram sequence duration was 194 days during 2020-21 and 197 days during 2021-22.

Table 7: Economics of wheat-summer green gram sequence as influenced by integrated 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	Green gram	Sequence		
Main plot: Nitrogen management in wheat								
N_1	6541	22.07	146191	77271	28427	105698	42783	1.40
N_2	6732	22.07	150460	70634	28427	99061	53755	1.54
N_3	7505	22.07	167737	43669	28427	72096	98268	2.36
N_4	7464	22.07	166820	52287	28427	80714	88719	2.10
N_5	7749	22.07	173190	60564	28427	88991	86911	1.98
N_6	6942	22.07	155154	69334	28427	97761	59822	1.61
Sub plot: Levels of nitrogen in summer green gram								
L_1	6900	22.07	154215	62293	28361	90654	65976	1.73
L_2	7276	22.07	162619	62293	28427	90720	74445	1.82
L_3	7291	22.07	162954	62293	28493	90786	74720	1.82

Table 8: Economics of wheat-summer green gram sequence as influenced by different treatment combinations of main and sub plot treatments (Average of 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	Green gram	Sequence		
N_1L_1	6306	22.07	140939	77271	28361	105632	37514	1.36
N_1L_2	6712	22.07	150013	77271	28427	105698	46664	1.44
N_1L_3	6607	22.07	147666	77271	28493	105764	44215	1.42
N_2L_1	6711	22.07	149991	70634	28361	98995	53345	1.54
N_2L_2	6650	22.07	148628	70634	28427	99061	51894	1.52
N_2L_3	6834	22.07	152740	70634	28493	99127	56005	1.56
N_3L_1	7194	22.07	160786	43669	28361	72030	91274	2.27
N_3L_2	7655	22.07	171089	43669	28427	72096	101673	2.41
N_3L_3	7665	22.07	171313	43669	28493	72162	101834	2.41
N_4L_1	7230	22.07	161591	52287	28361	80648	83473	2.04
N_4L_2	7636	22.07	170665	52287	28427	80714	92623	2.15
N_4L_3	7526	22.07	168206	52287	28493	80780	90060	2.11
N_5L_1	7210	22.07	161144	60564	28361	88925	74742	1.84
N_5L_2	8020	22.07	179247	60564	28427	88991	93063	2.05
N_5L_3	8017	22.07	179180	60564	28493	89057	92929	2.04
N_6L_1	6747	22.07	150795	69334	28361	97695	55462	1.57
N_6L_2	6982	22.07	156048	69334	28427	97761	60730	1.62
N_6L_3	7097	22.07	158618	69334	28493	97827	63275	1.65

References

1. Braun HJ, Atlin G, Payne T. In: Reynolds CRP, editor. Climate change and crop production. CABI, London, UK; c2010.
2. Gudadhe NN, Imade SR, Thanki JD. Effect of integrated nutrient management on rice-green gram cropping sequence. Legume Research. 2020;LR-4307.
3. Jangir R, Thanki JD, Patil KB, Saini LK. Residual and direct effect of integrated nutrient management on growth, yield, monetary efficiency, nutrient uptake of cowpea and soil properties under grain amaranth (*Amaranthus hypochondriacus* L.) - cowpea [*Vigna unguiculata* (L.) Walp] cropping sequence in Inceptisols of Western India. Journal of Plant Nutrition. 2021;1-21.
4. Khorne GW, Ahire RD, Tanpure MU. Economic analysis of processing of green gram mill's in Maharashtra. Int. J Adv. Chem. Res. 2022;4(2):242-247. DOI: 10.33545/26646781.2022.v4.i2d.105
5. Mahapatra A, Mishra GC, Barik AK. Integrated nutrient management in baby corn and its residual effect on green

gram under rainfed ecosystem of Odisha. International Journal of Agriculture, Environment and Biotechnology. 2018;11(3):433-438.
6. Mangaraj S, Paikaray RK, Satapathy MR, Swain B. Effect of organic and inorganic nutrient sources combination on short grain aromatic rice-green gram cropping system. Journal of Crop and Weed. 2021;17(2):47-51.
7. Mansuri RN. Effect of integrated nutrient management in rice-chickpea cropping sequence under south Gujarat condition. Ph.D thesis submitted to the Navsari Agricultural University, Navsari (Gujarat); 2016.
8. Mondal SS, Kundu R, Brahmachari K, Bera PS, Acharya D. Effect of integrated nutrient management on the productivity, quality improvement and soil fertility in rice-onion-cowpea sequence. Oryza. 2014;51(3):208-212.
9. Panse VG, Sukhatme PV. Statistical Method for Agricultural workers, I. C. A. R., New Delhi; c1967. p. 199-200.
10. Patil JB, Arvadia MK, Thorave DS. Effect of integrated nitrogen management on yield, economics and soil properties in sorghum-green gram cropping sequence under South Gujarat. International Journal of Chemical Studies. 2018;6(1):1098-1102.
11. Yadav SK, Babu S, Singh Y, Yadav MK, Yadav GS, Pal S, Singh R, Singh K. Effect of organic nutrient sources on yield, nutrient uptake and soil biological properties of rice (*Oryza sativa*) based cropping sequence. Indian Journal of Agronomy. 2013;58(3):70-75.
12. Lakshmi CSR, Rao PC, Sreelatha T, Madahvi M, Padmaja G, Rao PV, *et al*. Nitrogen use efficiency and production efficiency of rice under rice-pulse cropping system with integrated nutrient management. Journal of Rice Research. 2012;5(1&2):42-49.