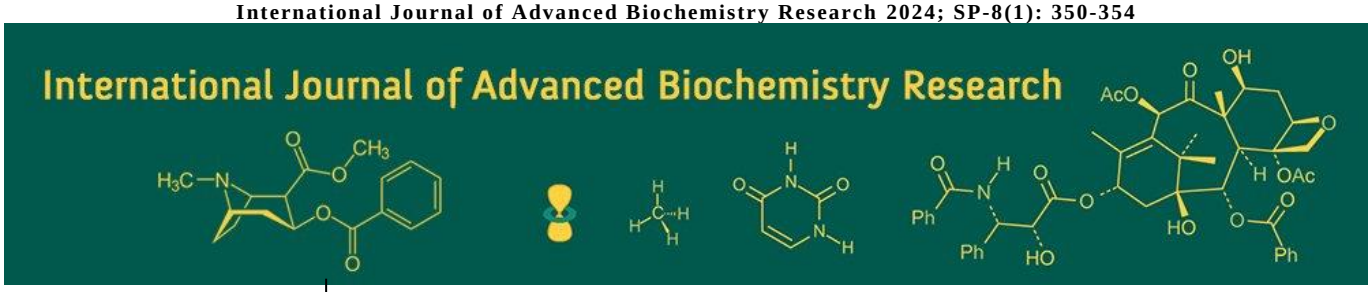

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Effect of integrated nutrient management on yield and quality parameter of wheat (*Triticum aestivum*): Summer green gram (*Vigna radiata* L.) cropping sequence in middle Gujarat condition

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Abstract
A field experiment was conducted at A field experiment was conducted at Tribal Research cum Training Centre Farm, Anand Agricultural University, Devgadh Baria, Gujarat, during the winter (*rabi*) and summer seasons 2019-20 and 2020-21, to study the effect of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.) and its residual effect on succeeding green gram (*Vigna radiata* L.) under irrigated condition. The experiment was laid out in a randomized block design with 10 treatments and 4 replications. Application of 100% recommended dose of fertilizer (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$) resulted in the higher grain (4114 kg ha^{-1}) and stover yield (5662 kg ha^{-1}) as well as protein content (12.52%) and protein yield (515 kg ha^{-1}) wheat crop. In succeeding green gram crop, residual effect of application of 100% recommended dose of fertilizer (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$) recorded higher grain (1215 kg ha^{-1}) and haulm yield (2735 kg ha^{-1}) along with protein content (20.78%) and protein yield (253 kg ha^{-1}) of crop.

Keywords: INM, wheat, green gram, yield, protein, %, Bio NPK, FYM, gypsum

Introduction
Wheat is the second important staple food crop in India next to the China, rice being the first. India is the 2nd largest producer of wheat all over the world. Around 12% of wheat produced all over the world is produced in India. In India, wheat is grown in an area of 31.61 million hectares with total production of 109.52 million tonnes with productivity of 3502 kg ha^{-1} While, in Gujarat wheat is grown over an area of 1.35 million hectares with an annual production of 3.40 million tonnes with the productivity of 3019 kg ha^{-1} (Anon., 2021) [1]. Junagadh, Rajkot, Ahmedabad and Sabarkantha are the major wheat producing districts in Gujarat. (DoA, Gujarat, 2021b) [3].

Integrated nutrient management give the valuable information about the effect of chemical fertilizer alone and in combination with organic manure on the soil fertility and crop productivity under intensive cropping. There is an apprehension that the use of chemical fertilizers over the years may impair the soil fertility. In continuous cropping, use of imbalanced nutrients (N or NP alone) through inorganic fertilizers without organic manure cannot sustain the desired level of crop production. Integration of inorganic with organic manures will not only sustain the crop production, but also will be effective in improving soil health and enhancing the nutrient use efficiency.

Bio-fertilizers play a vital role in the increasing availability of nitrogen and phosphorus. It increases the biological fixation of atmospheric nitrogen and enhances phosphorus availability to crops. Therefore, the introduction of bio NPK consortium (*Azotobacter*, *Azospirillum* and 3 Bacillus species) may be helpful. It is a liquid bio-fertilizer that saves costly chemical fertilizers by 25–30% with a 10– 15% increase in crop production. (Vyas *et. al* 2016) [13].

Farmyard manure occupies important position among the organic manures. The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process or by cell permeability or by hormonal growth action. It supplies N, P and K in available form to the plant through biological decomposition, it contains 0.50, 0.17 and 0.55 percent of N, P and

K, respectively (Patel *et al*. 1992) [8]. FYM release many organic and inorganic acids during decomposition and convert unavailable soil phosphorus into available form and easily available to plants. The higher polytonal content in vermicompost and FYM treated plots may be the cause for low pest build up in these plots (Surekha and Rao, 2001) [12]. Considering these facts in mind present investigation was carried to find out the Effect of integrated nutrient management on yield of wheat (*Triticum aestivum* L.) and its residual effect on succeeding green gram (*Vigna radiata* L.)

Materials and Methods

A field experiment was conducted at Tribal Research cum Training Centre Farm, AAU, Devgadh Baria, Gujarat. ($22^0$42 N, $73^0$54 E 104 meters above the mean sea level), during the *Rabi* and summer seasons of 2019-20 and 2020-21 to study the effect of integrated nutrient management on yield of wheat (*Triticum aestivum* L.). During experimentation, the *rabi* crop received no rainfall during the both year 2019-20 and 2020-21. In general, the climate remained congenial, providing a good and healthy environment for the successful cultivation of wheat in winter and green gram in summer season during both the years of experimentation. The maximum temperature ranged from 15.0^0 to 33.04^0 C minimum temperature ranged from 7.4^0 to 24.4^0 C during *rabi* crop season (Nov-March) of the years 2019-20, respectively. The maximum and minimum temperature during *rabi* season (November-March) ranged from 15.0^0 to 39.3^0 C and 7.8^0 to 24.0^0 C during 2020-21, respectively. The soil of the experimental field at 0– 15 cm depth was low in organic carbon (0.43%) and available N (218.50 kg ha^{-1}), medium in available P_2O_5 (26.56 kg ha^{-1}) and high in available K_2O (258.51 kg ha^{-1}) and neutral (7.1 pH) in reaction. The wheat variety 'GW 451' (Gujarat wheat 451) is new high yielding (4210 kg ha^{-1}), timely sown and early maturing variety (95-113 days) in irrigated condition. The green gram variety GM- 5 has long pod with more seeds (10-12) per pod and early maturing variety (60-65 days). It is highly resistant to Yellow Mosaic Virus (YMV). The variety has 5.1 g of 100 seed weight. It produces 32.15 and 15.27 percent higher grain yield over the check varieties GM 4, respectively.

Ten treatments on integrated nutrient management *viz.*, 120:60:00 NP kg ha^{-1} (RDF) (T_1), 120:60:40 NPK kg ha^{-1} (T_2), 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 10 t ha^{-1} (T_3), 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium (T_4), 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} ZnSO4 (T_5), 90:45:40 NPK kg ha^{-1} + FYM @ 1.5 t ha^{-1} (T_6), 90:45:00 NP kg ha^{-1} + FYM @ 2.5 t ha^{-1} (T_7), 90:45:00 NP kg ha^{-1}+ FYM @ 10 t ha^{-1} (T_8), 90:45:00 NP kg ha^{-1}+ FYM @ 5 t ha^{-1} + NPK consortium (T_9), 90:45:00 NP kg ha^{-1}+ FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} ZnSO4 (T_{10}) were tested in randomized block design with 4 replications. The wheat crop was fertilized with half dose of nitrogen (60 kg ha^{-1}) as well as entire quantity of phosphorus (60 kg ha^{-1}) and potash (40 kg ha^{-1}) through urea, Di-ammonium phosphate (DAP) and Murate of Potash (MOP), respectively as basal application at time of sowing. Remaining 60 kg nitrogen in the form of urea was top dressed at 30 days after sowing.

The organic manures, fertilizers and bio-fertilizers were applied in the experimental plots before sowing as per the treatments. Treatment-wise manures were manually incorporated in soil 10 days before sowing of the crop. Small furrows were opened manually in each plot, keeping the distance of 22.5 cm between the rows and fertilizers were applied uniformly in the furrows at the time of sowing. The NPK consortium was applied as per the treatments.

Wheat GW 451 was sown on 5th November 2019 and 10th November 2020, with seed rate of 120 kg ha^{-1} and 'GM -5' was sown on 18th March 2020 and 4th March 2021, with the seed rate of 25 kg ha^{-1}. Sowing was done with 1 pre-sowing irrigation. Total 7 irrigations in wheat and 7 irrigations in green gram were given to maintain appropriate moisture level during crop period. Thinning of green gram was done manually at 15 days after sowing during experimentation to maintain proper plant stand as per geometry.

When the crop was physiologically matured, five randomly selected, previously tagged plants were harvested separately to record post-harvest observations. The crop was harvested at maturity by cutting close to the ground with the help of sickle. The border lines were harvested first and removed from the experimental area. Then, net plot area was harvested and the produce was allowed to sun dry in the respective plots for 4 to 5 days. The plot wise threshing and cleaning operations were carried out subsequently. The seed yield was recorded and stover yield was computed by subtracting the seed yield from the total biological yield of each plot.

The pods of green gram are allowed to sun dry in the threshing yard. After complete sun drying, the weight of total produce was recorded for each plot separately. The seed yield of each net plot was recorded after threshing and cleaning of seeds. The plants were uprooted from the net plot and sun dried in threshing yard. The haulm yield of each net plot was also recorded by tying into bundles and weighed for recording weight of haulm separately for each plot. The protein content in the seeds was calculated by multiplying nitrogen content (%) of seed with the conversion factor of 6.25 as reported by Gupta *et al.* (1973). Protein yield per plot was calculated by multiplying protein content of seed with the seed yield (kg ha^{-1}) which is divided by 100.

The statistical analysis was carried out as described by Cochran and Cox (1967) [2]. The values of calculated "F" was worked out and compared with the value of table "F" at 5 percent level of significance. The value of S.Em. ± and co-efficient of variation (C.V.%) was also calculated. The pooled analysis of the 2 years' data was carried out as per procedure suggested by Cochran and Cox (1967) [2].

Results and Discussion

Yield of wheat: Among all the treatments, T_5 [Application of 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1}(gypsum) + 10 kg ha^{-1} $ZnSO_4$] resulted in higher grain (4234, 3993 and 4114 kg ha^{-1}) and straw yield (5539, 5784 and 5662 kg ha^{-1}) during 2019-20, 2020-21 and on pooled basis, respectively and it was closely related to the treatments T_4 (120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium) seed (3980, 3774 and 3877 kg ha^{-1}) and straw yield (5310, 5484 and 5397 kg ha^{-1}) (table 1). The increase in grain yield was due to increase in the yield attribute as the level of nitrogen was increased. Increased supply of nitrogen to plant promotes flowering and fruiting, higher manufacture of food and its subsequent partitioning in sink. The application of organic and inorganic sources of nutrients with 100% NPK also produced better growth parameters *viz*., plant height, number of effective tillers and finally dry matter. Farmyard

manure occupies important position among the organic manures. The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process or by cell permeability or by hormonal growth action. Steady decomposition of farm yard manure and release of nutrients throughout the crop growth period coupled with better nutrient assimilation in developing reproductive structures, greater availability of metabolites (photosynthates), have resulted positive information of yield components which ultimately improved the yield of the crop. Zahoor (2014) [15], Kumar *et al*. (2015) [5], Singh *et al*. (2016) [11] and Maurya *et al.* (2019) [6].

Table 1: Effect of integrated nutrient management on grain and straw yield of wheat

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1: 120:60:00 NP kg ha $^{-1}$ (RDF)	3284	3469	3377	4594	4488	4541
T_2: 120:60:40 NPK kg ha^{-1}	3590	3502	3546	4949	4959	4954
T_3: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 10 t ha^{-1}	3610	3541	3576	5102	5156	5129
T_4: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium	3980	3774	3877	5310	5484	5397
T_5: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha $^{-1}$ (gypsum) + 10 kg ha^{-1} $ZnSO_4$	4234	3993	4114	5539	5784	5662
T_6: 90:45:40 NPK kg ha^{-1} + FYM @ 1.5 t ha^{-1}	2772	2858	2815	4315	4205	4260
T_7: 90:45:00 NP kg ha^{-1} + FYM @ 2.5 t ha^{-1}	2812	2939	2876	4372	4235	4304
T_8: 90:45:00 NP kg ha^{-1} + FYM @ 10 t ha^{-1}	2950	3075	3013	4422	4327	4375
T_9: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium	2947	3005	2976	4375	4327	4351
T_{10}: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha $^{-1}$ (gypsum) + 10 kg ha^{-1} $ZnSO_4$	3155	3149	3152	4472	4364	4418
S.Em. ±	227	221	159	297	301	211
C. D. at 5%	659	643	450	861	872	599
C.V.%	13.62	13.30	13.46	12.50	12.70	12.60
Y						
S.Em. ±			71			94
C. D. at 5%			NS			NS
Y x T Interaction						
S.Em. ±			224			299
C. D. at 5%			NS			NS

Yield of succeeding green gram

Regarding residual effect, significantly higher seed yield (1201, 1230 and 1215 kg ha^{-1}) and haulm yield (2756, 2714 and 2735 kg ha^{-1}) during 2020, 2021 and on pooled basis (table 2.) recorded under the application of 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1}(gypsum) + 10 kg ha^{-1}$ZnSO_4$ (T_5), which was closely related to the treatments T_4 (120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium). The increased green gram seed yield might be due to addition of FYM to preceding crop resulting in improvement in soil structure which reduced the soil crusting and also serves as a source of energy for soil microflora which resulted in better root nodulation and nitrogen fixation. It is confirmed by Meena *et al.* (2012) [7] and Singh (2016) [11].

Table 2: Residual effect of integrated nutrient management on seed and haulm yield of green gram

Treatment	Seed yield (kg ha^{-1})			Haulm yield (kg ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled
T_1: 120:60:00 NP kg ha $^{-1}$ (RDF)	794	808	801	1898	1891	1895
T_2: 120:60:40 NPK kg ha^{-1}	879	889	884	2062	1995	2028
T_3: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 10 t ha^{-1}	955	961	958	2234	2174	2204
T_4: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium	1138	1152	1145	2623	2592	2607
T_5: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha $^{-1}$ (gypsum) + 10 kg ha^{-1} $ZnSO_4$	1201	1230	1215	2756	2714	2735
T_6: 90:45:40 NPK kg ha^{-1} + FYM @ 1.5 t ha^{-1}	479	508	494	1157	1158	1158
T_7: 90:45:00 NP kg ha^{-1} + FYM @ 2.5 t ha^{-1}	527	544	535	1270	1284	1277
T_8: 90:45:00 NP kg ha^{-1} + FYM @ 10 t ha^{-1}	624	625	625	1481	1464	1473
T_9: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium	578	576	577	1386	1297	1341
T_{10}: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha $^{-1}$ (gypsum) + 10 kg ha^{-1} $ZnSO_4$	706	727	716	1678	1658	1668
S.Em. ±	57	53	39	128	110	84
C. D. at 5%	166	154	110	371	319	239
C.V.%	14.50	13.20	13.85	13.80	12.06	12.97
Y						
S.Em. ±			17			38
C. D. at 5%			NS			NS
Y x T Interaction						
S.Em. ±			55			119
C. D. at 5%			NS			NS

Quality of wheat

Application with 120:60:00 NP kg ha^{-1}(RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$ (T_5) significantly gives higher protein content (12.36, 12.69 and 12.52%) and protein yield (523, 506 and 515 kg ha^{-1}) during 2020, 2021 and on pooled basis and it is closely at par with the treatment T_4 (120:60:00 NP kg ha^{-1}(RDF) + FYM @ 5 t ha^{-1} + NPK consortium) (table 3). It might be due to Assimilation of nitrogen ions in definite deficient population, increasing the availability of nutrient, usually results in better uptake of nutrients by plants, which have increased the nitrogen metabolism leading to high nutrient content in the wheat grains and straw and due to higher seed yield it produce greater protein content as well as protein yield in the wheat crop. Similar results were obtained by Rana and Singh (2006) [9], Singh and Singh (2011) [4], Singh *et al.* (2016) [11] and Yadav *et al.* (2015) [14].

Table 3: Effect of integrated nutrient management on protein content and protein yield of wheat

Treatment	Protein content (%)			Protein yield (kg ha^{-1})		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1: 120:60:00 NP kg ha^{-1} (RDF)	12.24	12.10	12.17	402	420	411
T_2: 120:60:40 NPK kg ha^{-1}	12.26	12.14	12.20	440	425	432
T_3: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 10 t ha^{-1}	12.33	12.39	12.36	446	438	442
T_4: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium	12.34	12.47	12.41	492	472	482
T_5: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$	12.36	12.69	12.52	523	506	515
T_6: 90:45:40 NPK kg ha^{-1} + FYM @ 1.5 t ha^{-1}	11.85	11.58	11.71	328	331	330
T_7: 90:45:00 NP kg ha^{-1} + FYM @ 2.5 t ha^{-1}	12.07	11.92	12.00	340	351	345
T_8: 90:45:00 NP kg ha^{-1} + FYM @ 10 t ha^{-1}	12.21	12.09	12.15	361	372	367
T_9: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium	12.20	12.08	12.14	360	364	362
T_{10}: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$	12.23	12.10	12.16	387	382	384
S.Em. ±	0.20	0.21	0.15	30	30	21
C. D. at 5%	NS	NS	0.41	88	87	60
C.V.%	3.24	3.51	3.38	14.84	14.70	14.77
Y						
S.Em. ±			0.06			10
C. D. at 5%			NS			NS
Y x T Interaction						
S.Em. ±			0.21			30
C. D. at 5%			NS			NS

Quality of succeeding green gram

Higher protein content (20.73, 20.83 and 20.78%) and protein yield (249, 256 and 253 kg ha^{-1}) during 2020, 2021 and on pooled basis was recorded under application of 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1}(gypsum) + 10 kg ha^{-1} $ZnSO_4$ (T_5). However, it was significantly at par with T_1 (120:60:00 NP kg ha^{-1} (RDF), T_2 (120:60:40 NPK kg ha^{-1}), T_3 (120:60:00 NP kg ha^{-1}(RDF) + FYM @ 10 t ha^{-1}) T_4 (120:60:00 NP kg ha^{-1}(RDF) + FYM @ 5 t ha^{-1} + NPK consortium) (table 4). This might be due to increased nutrient especially N and P in organic manures that increased the mineralization synthesis in turn increased protein. This was supported by Singh *et al.*, (2013) [10].

Table 4: Effect of integrated nutrient management on protein content and protein yield of green gram

Treatment	Protein content (%)			Protein yield (kg ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled
T_1: 120:60:00 NP kg ha^{-1} (RDF)	20.55	20.52	20.53	163	166	164
T_2: 120:60:40 NPK kg ha^{-1}	20.64	20.59	20.62	181	183	182
T_3: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 10 t ha^{-1}	20.64	20.70	20.67	197	199	198
T_4: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium	20.67	20.73	20.70	235	239	237
T_5: 120:60:00 NP kg ha^{-1} (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$	20.73	20.83	20.78	249	256	253
T_6: 90:45:40 NPK kg ha^{-1} + FYM @ 1.5 t ha^{-1}	20.30	20.41	20.35	97	104	100
T_7: 90:45:00 NP kg ha^{-1} + FYM @ 2.5 t ha^{-1}	20.33	20.42	20.37	107	111	109
T_8: 90:45:00 NP kg ha^{-1} + FYM @ 10 t ha^{-1}	20.48	20.45	20.47	128	128	128
T_9: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium	20.44	20.42	20.43	118	117	118
T_{10}: 90:45:00 NP kg ha^{-1} + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$	20.50	20.47	20.48	145	149	147
S.Em. ±	0.14	0.12	0.09	12	11	8
C. D. at 5%	NS	NS	0.26	34	33	23
C.V.%	1.37	1.16	1.27	14.61	13.62	14.11
Y						
S.Em. ±			0.04			4
C. D. at 5%			NS			NS
Y x T Interaction						
S.Em. ±			0.13			12
C. D. at 5%			NS			NS

Conclusion

On the basis of the present findings, it can be concluded that the Application of 100% recommended dose of fertilizer (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$) resulted in the higher grain (4114 kg ha^{-1}) and straw yield (5662 kg ha^{-1}) as well as protein content (12.52%) and protein yield (515 kg ha^{-1}) of wheat crop. In succeeding green gram crop, residual effect of application of 100% recommended dose of fertilizer (RDF) + FYM @ 5 t ha^{-1} + NPK consortium + Sulphur @ 20 kg ha^{-1} (gypsum) + 10 kg ha^{-1} $ZnSO_4$) recorded higher grain (1215 kg ha^{-1}) and haulm yield (2735 kg ha^{-1}) along with protein content (20.78%) of crop.

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