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Effect of integrated nutrient management on growth, yield and quality of groundnut (*Arachis hypogaea* L.) under north Gujarat condition

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Abstract
A field experiment titled "Integrated nutrient management on growth, yield, and quality of groundnut (*Arachis hypogaea* L.) under North Gujarat condition" was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat in the *kharif* seasons of 2022 and 2023. The experiment was laid out in a randomized block design with five treatments and four replications. The pooled results indicated that application of 75% RDF + Vermicompost 2 t ha^{-1} to groundnut crop recorded significantly higher growth parameters, yield attributes and yield *viz*., plant height at harvest (45.42 cm), number of pods per plant (18.15), pod weight per plant (13.53), pod (2343 kg ha^{-1}) and haulm (3802 kg ha^{-1}) yield as well as protein content (22.20%) in kernel of groundnut. However, application of 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB recorded significantly higher number of root nodules per plant (66.70), fresh (256.8 mg) and dry (95.73 mg) weight of root nodule per plant at flowering stage of groundnut crop.

Keywords: INM, groundnut, yield, quality, vermicompost, *Rhizobium*, PSB

Introduction
Groundnut (*Arachis hypogaea* L.) commonly referred to as the "POOR MAN'S ALMOND," is an annual herbaceous legume that is autotetraploid and self-pollinating. Such a plant exists, and every component of it boosts the farmer's income. Ranking 13th among food crops and 4th in importance among oilseed crops worldwide, it is the world's greatest source of edible oil (Ramanathan, 2001) [14]. The crop has its own importance due to high edible oil and nutritional value of kernel as human food and haulm as rich feed for animal. The groundnut kernel contains 45-50 per cent edible oil, which is generally used in the preparation of soaps, cosmetics and cold creams besides as cooking medium. The kernel has high quality easily digestible protein, on an average 25.3 per cent which is about 1.3 times higher than meat, 2.5 times higher than eggs. The kernel also contain carbohydrates (6.0 to 24.9%), minerals and vitamins (Das, 1997) [4].
Gujarat, known as the "bowl of groundnut," is the largest producer of groundnut in the country, accounting for 40% of total production. The Saurashtra region, particularly North Gujarat, is experiencing significant growth in groundnut cultivation due to favorable agroclimatic conditions and coarse soil. Groundnut area, production and productivity of Gujarat were 1.76 million hectares, 4.53 million tonnes and 2570 kg ha^{-1}, respectively (Anonymous, 2023) [1].
India rank first in the world in respect of area and second in production after China. India is the second largest producer of groundnut in the world which produces around 10.30 million tonnes of groundnut from 4.96 million hectares of land and 2075 kg ha^{-1} productivity under irrigation (Anonymous, 2023) [1].
The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing environmental pollution. In coming decades a major issue in designing sustainable agricultural system will be the management of soil organic matter and the rational use of organic inputs such as animal manures, crop residues, green manures, sewage, sludge and food industry waste. However, since organic manures cannot meet the total nutrients need of modern agriculture, integrated use of nutrients from fertilizers and organic sources

seems to be a need of the time. The basic concept underlying the integrated nutrient management system (INMS), nevertheless, is the maintenance and possible improvement of soil fertility for sustained crop productivity on long term basis and also to reduce fertilizer input cost.

Materials and Methods

A field experiment entitled "Integrated nutrient management on growth, yield, and quality of groundnut (*Arachis hypogaea* L.) under North Gujarat condition " was conducted during *kharif* season of 2022 and 2023, in plot number C-18 and C-13, respectively at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). The soil of the experimental field in 2022 and 2023 were loamy sand in texture, low in organic carbon, available nitrogen, medium in available phosphorus, potash, sulphur and DTPA - extractable Mn while in 2022 medium in DTPA - extractable Fe and high in DTPA - extractable Zn and Cu. Whereas, in 2023 low in DTPA - extractable Fe and medium in DTPA - extractable Zn and Cu. EC was normal showing that the soil was free from salinity hazard.

There were five treatments comprising different recommended doses of fertilizers (RDF: 12.5: 25: 00: 25 kg N: P_2O_5: K_2O: S ha^{-1}), organic manures with and without biofertilizers *viz.*, T_1: 100% RDF, T_2: 75% RDF + FYM 5 t ha^{-1}, T_3: 75% RDF + Vermicompost 2 t ha^{-1}, T_4: 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB, T_5: 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB to groundnut and replicated four times in Randomized Block Design. In *kharif*, groundnut (TG 37 A) was sown at 45 cm spacing with seed rate of 120 kg seed ha^{-1}. The observations were collected during the course of study including plant height, number of pods per plant, pod weight per plant, 100 kernel weight, pod yield, haulm yield, shelling percentage. The estimation of nitrogen content in kernel was done by adopting the micro kjeldahl's method as described by Jackson (1973) [7]. Protein content (%) in kernel was computed by multiplying the nitrogen content with 6.25 as suggested by Gupta *et al*. (1973) [6] and oil content (%) in kernel was estimated by standard method suggested by Tiwari *et al*. (1974) [15]. The collected data for various parameter were statistically analysed by method as suggested by Panse and Sukhatme (1967) [11].

Results and Discussion

Growth attributes

An examination of data indicated that the different treatments tried in the experiment did not exert any significant effect on the plant count at 30 DAS and harvest during both years of experiment and in pooled study.

Data analysis (Table 1) showed that the application of 75% RDF + Vermicompost 2 t ha^{-1} (T_3) resulted in noticeably higher plant height (45.88, 44.96, and 45.42 cm in 2022, 2023 and pooled, respectively) and which was at par with 75% RDF + FYM 5 t ha^{-1} (T_2) and 100% RDF (T_1) during the both year as well as in pooled study. On pooled data basis, the magnitude of increased in plant height at harvest under treatment T_3 was to the tune of 7.19, 4.80, 23.58 and 16.60% over treatment T_1, T_2, T_4 and T_5, respectively. This result may be attributed to ready availability of nitrogen through inorganic fertilizers and vermicompost during the vegetative crop growth period. These findings are in close conformity with Bhosale and Pisal (2017) [3] in groundnut and Konthoujam *et al*. (2013) [9] as well as Pandey *et al*. (2022) [12] in soybean.

Number of root nodule per plant (Fig. 1) at flowering (68.35, 65.05 and 66.70 in 2022, 2023 and pooled, respectively) recorded significantly higher with 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB (T_5) during both year and in pooled study, which was remained statically at par with 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB (T_4) during both year and in pooled study and 75% RDF + Vermicompost 2 t ha^{-1} (T_3) during the both the years of experiment. It might be due to great availability of macro and micro nutrients from organic, inorganic and biological sources. Phosphorus has a specific role in nodule initiation, growth and function in addition to its role in host plant growth. Microorganisms with phosphate solubilizing potentially increase the availability of soluble phosphate and enhance the plant growth by improving biological nitrogen fixation. The results confirm the findings of Konthoujam *et al*. (2013) [9] in soybean and Kumar *et al*. (2019) [10] in groundnut as well as Pandey *et al*. (2022) [12] in soybean.

Significantly higher fresh and dry weight of root nodules per plant (Fig. 1) at flowering (363.8, 249.8 and 256.8 mg) and (98.43, 93.04 and 95.73 mg) in 2022, 2023 and pooled, respectively registered with application of 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB (T_5) during both year as well as in pooled study and it was found statically at par with 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB (T_4) during both year and pooled study and with 75% RDF + Vermicompost 2 t ha^{-1} (T_3) during the both year of experiment. The increase dry weight of root nodules might be due to more number of nodules per plant, availability of abundant organic matter and effective microbial activities because of sufficient supply of feeding material for *Rhizobium* bacteria in the form of humus. Similar findings have also supported by Konthoujam *et al*. (2013) [9] in soybean and Donga and Mathukia (2021) [5] in groundnut.

Yield attributes and yield

Data on a higher number of pods per plant (18.55, 17.75, and 18.15 in 2022, 2023 and pooled, respectively) were observed when 75% RDF + Vermicompost 2 t ha^{-1} (T_3) was applied in both the year of experiment and the pooled study (Table 1). This was statistically comparable to the application of 75% RDF + FYM 5 t ha^{-1} (T_2) and 100% RDF (T_1) in both the year of experiment and the pooled study. The percent increase in number of pods per plant at harvest was to the tune of 7.56, 3.42, 38.81 and 23.26 over treatment T_1, T_2, T_4 and T_5, respectively. The higher number of pods per plant could be because of the combined effect of vermicompost and inorganic fertilizers that provided balanced nutrition throughout growth period resulted in favourable effect on pod formation. These results are in agreement with the findings of Konthoujam *et al*. (2013) [9] in soybean, Jesal and Patel (2021) [8] in groundnut and Pandey *et al*. (2022) [12] in soybean.

Application of 75% RDF + Vermicompost 2 t ha^{-1} (T_3) gave significantly higher pod weight per plant (13.70, 13.37 and 13.53 g in 2022, 2023 and pooled study, respectively) which was statically at par with 75% RDF + FYM 5 t ha^{-1} (T_2) and 100% RDF (T_1) in both the year of experiment as well as in pooled study (Table 1). Application of fertilizer along vermicompost and FYM increased the pods weight per plant significantly and further increased the pod and haulm yield of *kharif* groundnut. The increase in the pod weight could be due to continuous supply of macro and micro nutrient to the crop which help in photosynthesis, assimilation and translocation of photosynthate from source to sink. Jesal and Patel (2021) [8] and Vala *et al.* (2017) [16] also reported higher pod weight with the application of vermicompost and FYM.

Among different treatment, application of 75% RDF + Vermicompost 2 t ha^{-1} (T_3) gave significantly highest pod (2371, 2315 and 2343 kg ha^{-1}) and haulm yield (3840, 3765 and 3802 kg ha^{-1}) in 2022, 2023 and pooled, respectively in both year and pooled study, which was remained statistically at par with 75% RDF + FYM 5 t ha^{-1} (T_2) and 100% RDF (T_1) in both year of experiment as well as pooled study (Table 2). Higher pod yield could be attributed to favourable changes in physical and chemical characteristics of the soils which might have enabled better pod formation. Moreover, the positive influence of these treatments through immediate supply of nutrients from inorganic sources especially at the early stage of the crop and slow and steady supply of nutrients from vermicompost and FYM throughout the crop growth period improved adequate biomass production and improvement in yield parameters resulting in higher pod and haulm yield. Similar findings are reported by Ola *et al*. (2013) [11], Bhosale and Pisal (2017) [3], Kumar *et al*. (2019) [10], Jesal and Patel (2021) [8] and Arsalan *et al*. (2024) [2]. An examination of data indicated that the different INM treatments tried in the experiment did not exert any significant effect on 100 kernel weight and shelling percentage during both year and pooled study.

Table 1: Effect of integrated nutrient management on plant height, number of pod per plant and pod weight per plant of groundnut

Treatments	Plant height (cm) at harvest			Number of pod per plant			Pod weight per plant (g)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1: 100% RDF	42.70	42.04	42.37	17.80	15.95	16.88	13.26	12.27	12.77
T_2: 75% RDF + FYM 5 t ha^{-1}	44.02	42.65	43.33	18.05	17.05	17.55	13.49	12.86	13.17
T_3: 75% RDF + Vermicompost 2 t ha^{-1}	45.88	44.96	45.42	18.55	17.75	18.15	13.70	13.37	13.53
T_4: 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB	37.61	35.89	36.75	13.55	12.60	13.08	9.82	9.79	9.80
T_5: 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	39.23	38.68	38.95	14.80	14.65	14.73	10.65	10.60	10.62
S.Em.±	1.69	1.41	1.02	0.70	0.59	0.42	0.49	0.44	0.31
C. D. at 5%	5.20	4.35	2.96	2.16	1.81	1.27	1.52	1.36	0.92
Interaction (Y X T)									
S.Em.±	-	-	1.56	-	-	0.65	-	-	0.47
C. D. at 5%	-	-	NS	-	-	NS	-	-	NS
C.V. %	8.06	6.92	7.53	8.45	7.52	8.03	8.11	7.48	7.81

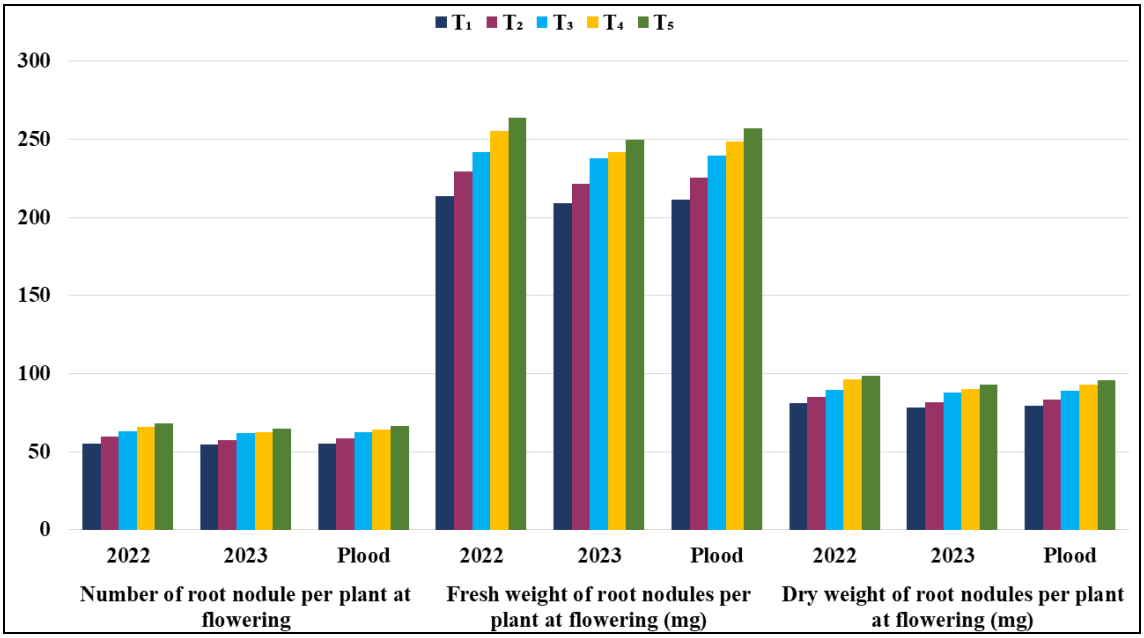

Fig 1: Effect of integrated nutrient management on number of root nodule, fresh and dry weight of root nodule per plant at flowering of groundnut

Table 2: Effect of integrated nutrient management on pod yield, haulm yield and 100 kernel weight of groundnut

Treatments	Pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})			100 kernel weight (g)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1: 100% RDF	2173	2106	2139	3565	3485	3525	43.02	42.78	42.90
T_2: 75% RDF + FYM 5 t ha^{-1}	2207	2120	2164	3657	3530	3594	43.67	43.46	43.57
T_3: 75% RDF + Vermicompost 2 t ha^{-1}	2371	2315	2343	3840	3765	3802	44.18	44.12	44.15
T_4: 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB	1819	1752	1786	3153	3002	3077	41.12	41.06	41.09
T_5: 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	1988	1942	1965	3393	3315	3354	41.91	41.86	41.88
S.Em.±	98	107	72	145	156	106	1.59	1.51	1.01
C. D. at 5%	301	329	211	445	481	311	NS	NS	NS
Interaction (Y X T)									
S.Em.±	-	-	102	-	-	150	-	-	1.55
C. D. at 5%	-	-	NS	-	-	NS	-	-	NS
C.V. %	9.25	10.44	9.84	8.21	9.13	8.67	7.41	7.06	7.24

Table 3: Effect of integrated nutrient management on shelling percentage, oil and protein content in kernel of groundnut

Treatments	Shelling percentage			Oil content in kernel (%)			Protein content in kernel (%)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1: 100% RDF	68.10	67.92	68.01	47.22	47.06	47.14	21.39	20.78	21.09
T_2: 75% RDF + FYM 5 t ha^{-1}	68.67	68.04	68.36	47.72	47.48	47.60	21.67	21.17	21.42
T_3: 75% RDF + Vermicompost 2 t ha^{-1}	69.29	68.82	69.05	48.26	48.03	48.14	22.38	22.03	22.20
T_4: 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB	66.12	65.11	65.61	46.06	45.76	45.91	19.54	19.05	19.29
T_5: 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	67.13	66.43	66.78	46.86	46.56	46.71	20.34	19.91	20.13
S.Em.±	1.35	1.44	0.98	0.97	1.20	0.77	0.59	0.63	0.40
C. D. at 5%	NS	NS	NS	NS	NS	NS	1.83	1.94	1.16
Interaction (Y X T)									
S.Em.±	-	-	1.40	-	-	1.09	-	-	0.61
C. D. at 5%	-	-	NS	-	-	NS	-	-	NS
C.V. %	3.98	4.29	4.14	4.12	5.10	4.63	5.64	6.10	5.87

Quality

Review of the data revealed that during the year and pooled study, the various INM treatments that were attempted in the experiment did not significantly affect the oil content in kernels. Since oil content is a genetic characteristic, agronomical methods do not significantly affect it.

Significantly higher protein content (22.38, 22.03 and 22.20% in 2022, 2023 and pooled study, respectively) in kernel of groundnut recorded with application of 75% RDF + Vermicompost 2 t ha^{-1} (T_3) which was statistically remained at par with 75% RDF + FYM 5 t ha^{-1} (T_2) and 100% RDF (T_1) in both year of experiments as well as pooled analysis. On pooled basis the magnitude of increase in protein content in kernel with the application of 75% RDF + Vermicompost 2 t ha^{-1} (T_3) was the tune of 5.29, 3.64, 15.07, 10.30% respectively over 100% RDF (T_1), 75% RDF + FYM 5 t ha^{-1} (T_2), 50% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB (T_4), 50% RDF + Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB (T_5), respectively. As nitrogen is the basic constituent of protein and with the increase in the availability of nitrogen by the application of organic manures with inorganic fertilizers, the uptake of nitrogen increased which resulted in higher protein content in kernel. Similar findings were also noted by Konthoujam *et al*. (2013) [9], Ola *et al*. (2013) [11] and Jesal and Patel (2021) [8].

Conclusion

Based on the two-year experimental findings, it is concluded that the combined application of organic manures and fertilizer had significant and positive effect on growth, yield and quality of groundnut crop. The application of 75% RDF (9.38: 18.75: 00: 18.75 kg N: P_2O_5: K_2O: S ha^{-1}) along with 2 t ha^{-1} of vermicompost recorded higher plant height, number of pod, pod weight, pod yield and haulm yield of groundnut. This nutrient management practice is effective in improving the protein content in kernel of groundnut.

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