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Enhancing Crop Productivity and Soil Health through Integrated Nutrient Management in Cash Crop Systems

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ABSTRACT

Integrated Nutrient Management (INM) is a sustainable approach aimed at enhancing crop productivity and maintaining soil health, particularly in cash crop systems. With the rising global population and increasing demand for food and agricultural products, the need for balanced nutrient management has become crucial. Conventional reliance on chemical fertilizers has led to soil degradation, nutrient imbalances, and environmental pollution. INM integrates organic manures, chemical fertilizers, andbiofertilizers to ensure optimal nutrient availability, improve soil properties, and reduce the adverse environmental impacts of excessive fertilizer use.This review highlights the role of INM in cash crops such as cotton, sugarcane, and potato, demonstrating its effectiveness in improving yield and soil health. Studies indicate that INM enhances nutrient use efficiency, promotes microbial activity, and sustains soil fertility in the long term. The combination of organic amendments like farmyard manure (FYM), compost, and biofertilizers with chemical fertilizers has shown significant improvements in crop productivity, nutrient uptake, and soil structure. Additionally, INM practices contribute to environmental sustainability by minimizing nutrient leaching and reducing greenhouse gas emissions.While INM presents a promising solution to the challenges of soil fertility depletion and declining yields, further research is needed to develop region-specific INM strategies and increase awareness among farmers regarding its benefits. The adoption of INM can serve as a long-term strategy for ensuring food security, sustaining soil health, and promoting eco-friendly agricultural practices.

Keywords: *Integrated Nutrient Management, crop productivity, soil health, cash crop*

Introduction

The current global population stands at approximately 7.2 billion and is projected to reach 9.6 billion by 2050 [1]. India, the second most populous country, is expected to see its population rise to 1.66 billion by the same year [2]. With this rapid population growth, cultivable land faces mounting pressure to meet the increasing demand for food and accommodate other human needs such as settlements and infrastructure development. Continuous cultivation of agricultural lands often leads to the depletion of essential soil nutrients. As noted by [3], food grain production in India has plateaued primarily due to the decline in soil health. Indian soils are deficient in essential plant nutrients, with the imbalanced use of fertilizers being a major contributor to soil degradation.

The Role of Fertilizers in Agriculture

Fertilizers have historically been instrumental in increasing crop productivity. However, the overuse of chemical fertilizers has caused several environmental issues, including groundwater pollution and greenhouse gas emissions. Consequently, there is a growing emphasis on integrating organic fertilizers with chemical inputs to not only enhance crop yields but also improve the physical, chemical, and biological properties of cultivated soils.

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In many developing countries, agricultural challenges arise from both the overuse and underuse of chemical fertilizers, leading to multi-nutrient deficiencies and reduced fertilizer efficiency. At the national level, India's nutrient application ratio of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) is currently distorted at 8.0:2.7:1, compared to the ideal ratio of 4:2:1. This imbalance adversely affects soil health and long-term productivity.

The Concept of Integrated Nutrient Management

Integrated Nutrient Management (INM) is a sustainable agricultural practice that combines the judicious use of chemical fertilizers, organic inputs, and biofertilizers to achieve a balanced nutrient supply. Its objectives are to enhance soil fertility, increase crop productivity, and maintain environmental health. Cash crops such as cotton, sugarcane, and tobacco, which have intensive nutrient demands, often deplete soil resources, leading to degradation. INM provides a viable solution to address these issues.

INM integrates various nutrient sources, such as compost, green manures, farmyard manure, chemical fertilizers, and bio-fertilizers, to optimize nutrient use efficiency and minimize environmental impact. According to [4], adopting INM strategies replenishes soil nutrients while improving the soil's biological, chemical, and physical properties. By reducing the heavy reliance on inorganic fertilizers, INM minimizes nutrient losses to the environment, thereby mitigating pollution. It serves as a global strategy to ensure food security and promote environmental sustainability.

Esilaba et al. (2005) emphasize that INM enhances soil conditions by improving its physical, chemical, biological, and hydrological properties. This holistic approach boosts farm productivity while minimizing land degradation, making it an essential component of sustainable agricultural systems.In conclusion, adopting INM practices is critical for addressing the challenges posed by population growth and the rising demand for food. By integrating various nutrient sources, INM not only improves crop productivity and soil health but also contributes to long-term environmental sustainability.

Importance of Integrated Nutrient Management (INM) in Cash Crop Systems

Cash crops require high nutrient inputs to achieve optimal yields. However, excessive reliance on chemical fertilizers in such systems has led to issues like soil degradation, reduced microbial activity, and nutrient leaching, which contaminates water bodies [6]. INM addresses these challenges by ensuring a balanced nutrient supply through a combination of organic and inorganic sources, promoting sustainable agriculture.

Advantages of Cash Crop Farming

- Cash crop farming is an effective approach to producing high quantities of affordable food.
- It is highly profitable for farmers, often serving as a major source of livelihood.
- It creates employment opportunities through crop processing and fosters economic diversification.
- It generates significant revenue for governments, contributing to the national economy.

Disadvantages of Cash Crop Farming

- Monocropping, often practiced in cash crop systems, involves cultivating the same crop repeatedly on the same land. This practice can limit the production of diverse food crops.
- Continuous monocropping leads to soil quality decline, increasing susceptibility to pests and diseases. This can result in crop failures, potentially causing food insecurity.
- Cash crop farming primarily benefits farmers with access to food security, resources, and income, while small-scale farmers may struggle with input constraints and economic risks.

Components of INM

Organic Manures

Organic manures, such as farmyard manure (FYM), compost, and vermin compost, play a critical role in enhancing soil organic carbon (SOC) levels. Research by [7] indicates that FYM application significantly improves soil structure, water retention capacity, and microbial activity, contributing to long-term soil health.

Manures, derived from animal, plant, and human residues, act as slow-releasing nutrient sources upon decomposition. Their application not only provides essential nutrients but also enhances soil physical properties, offering a residual effect that outlasts chemical fertilizers. Majorsourcesof manuresare (Fig. 1)

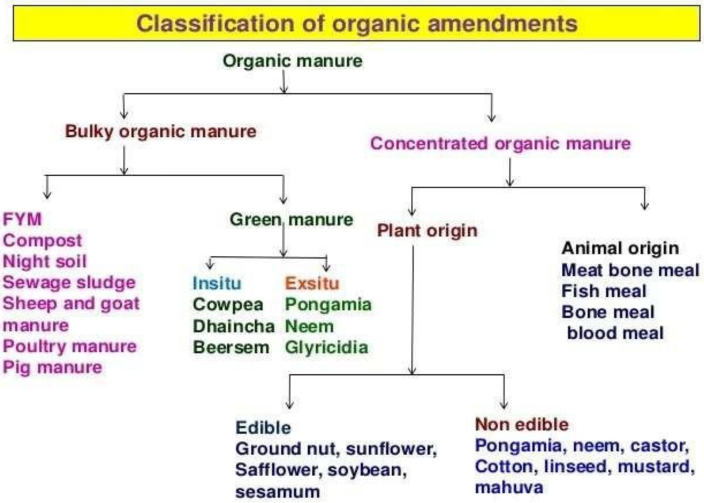

Fig. 1 Classification of organic amendments

Compost

Composting is the controlled decomposition of organic matter by microorganisms, converting waste like crop residues, animal manure, and municipal waste into nutrient-rich compost. The compost made from farm waste (e.g., paddy straw, sugarcane trash), containing ~0.5% N, 0.15% P_2O_5, and 0.5% K_2O is called farm compost. Nutrient content can be improved by adding 10–15 kg superphosphate/rock phosphate per ton during initial composting. The compost made from urban waste like night soil and street sweepings, with ~1.4% N, 1% P_2O_5, and 1.4% K_2O is called town compost.

Chemical Fertilizers

Chemical fertilizers supply readily available nutrients essential for high-yielding crops. However, excessive use can harm the soil and the environment. [8] highlight the importance of precise application to prevent imbalances and environmental damage.

Biofertilizers

Biofertilizers contain efficient microorganisms like Rhizobium and Azotobacter that enhance nutrient availability by fixing nitrogen and solubilizing phosphorus [9]. These eco-friendly inputs reduce reliance on synthetic fertilizers and promote sustainable agriculture.

Sl. No	Groups	Examples
N2 Fixing Biofertilizers		
1	Free-living	*Azotobacter,Beijerinkia,Clostridium, Klebsiella,Anabaena,Nostoc*
2	Symbiotic	*Rhizobium, Frankia, Anabaena,azollae*
3	AssociativeSymbiotic	*Azospirillum*
P Solubilizing Biofertilizers		
1	Bacteria	*Bacillus megaterium Var. Phosphaticum, Bacillus subtilis, Bacillus circulans, Pseudomonas striata*
2	Fungi	*Penicillium sp, Aspergillusawamori*
P Mobilizing Biofertilizers		
1	Arbuscularmycorrhiza	*Glomus sp.,Gigasporasp.,Acaulospora sp.,Scutellospora sp. &Sclerocystissp.*
2	Ectomycorrhiza	*Laccariasp.,Pisolithus sp., Boletus sp., Amanita sp.*
3	Ericoid mycorrhizae	*Pezizellaericae*
4	Orchid mycorrhizae	*Rhizoctoniasolani*
BiofertilizersforMicronutrients		
1	Silicateand Zinc solubilizers	*Bacillussp.*
Plant Growth Promoting Rhizo bacteria		
1	Pseudomonas	*Pseudomonasfluorescens*

Impact of INM on Crop Productivity

Integrated Nutrient Management (INM) has been recognized as an effective approach to enhance crop productivity by ensuring an adequate and balanced supply of essential nutrients. A two-year study conducted by [10] on Bt cotton demonstrated that the application of 100% RDF (240:50:150 kg ha^{-1})+ FYM 10 t ha^{-1} + *Azotobactor*10 ml kg^{-1} seed + PSB10mlkg^{-1}seed+KSB10mlkg^{-1}seed(T_9), significantly enhanced yield and yield attributes. This experiment, conducted in sandy loam soils of the North-West Agro-climatic Zone of Gujarat, highlighted the synergistic effects of integrating organic (FYM), inorganic (NPK), and biofertilizer inputs to sustainably improve crop productivity(Table 1&2).

A field experiment was conducted [11] on jute (Corchorus olitorius L.) during 2004–2006 to evaluate the impact of combining inorganic fertilizers with organic manures on yield, nutrient utilization, and soil fertility. The study revealed that substituting 25% of the recommended nitrogen dose with water hyacinth compost or farmyard manure significantly increased fiber yield (2.63 and 2.62 tonnes/ha, respectively) compared to the treatment with 100% NPK (Table 3).

The effect of INM on sugarcane productivity wasinvestigated [12] and found that applying FYM at 20 t/ha, combined with soil test-based nutrient application, resulted in the highest number of millable canes (134.3 thousand/ha) and shoots (142.2 thousand/ha) at 150 days after sowing. However, cane length, diameter, single cane weight, and sugar yield showed no significant differences when compared to treatments with 100% RDF plus FYM at 20 t/ha, or soil test-based nutrient application along with biofertilizers and 10 t/ha of FYM (Table 4).

[13] investigated the influence of nutrient management practices on nutrient dynamics and sugarcane performance. Their study revealed that applying 50% nitrogen through press mud and 50% through fertilizers resulted in a significantly higher cane yield (170.33 t/ha) compared to most other practices, except for treatment N7 (174.82 t/ha), which was statistically similar. Among the organic nutrient management strategies, the combination of press mud, FYM, French beans, and biofertilizers (N3) produced a significantly higher yield (132.02 t/ha) compared to N2, and it was comparable to other treatments, including the use of chemical fertilizers alone (N8). Additionally, the interaction effects were found to be statistically significant (Table 5).

The combined use of organic manure and chemical fertilizers significantly ($p \leq 0.05$) improved potato yieldreported by [14]. The highest yield (25.2 t ha^{-1}) was achieved in T7, where 3 t ha^{-1} of poultry manure (PM) combined with a reduced rate of recommended chemical fertilizers was applied. In contrast, the control recorded the lowest yields (14.1 t ha^{-1} in 2008–09 and 13.8 t ha^{-1} in 2009–10) (Table 6). Similar results were observed by [15], the highest cabbage head yield with the integrated application of 5 t ha^{-1} poultry manure and 70% of the recommended fertilizer dose, consistent with these findings. Comparable results were also noted by [16] and Thind et al. [17]. T7 also exhibited the highest number of stems per hill (7.69 in 2008–09 and 7.84 in 2009–10), followed by T6 (7.18 in 2008–09 and 6.93 in 2009–10) and T5 (6.87 in 2008–09 and 6.93 in 2009–10). Similar outcomes were reported by [18], with maximum plant height and stems per hill resulting from 75% RDF + 25% RDN through FYM. The highest number of tubers per hill was recorded in T7 (8.87 in 2008–09 and 9.50 in 2009–10), followed by T5 (7.88 in 2008–09 and 8.83 in 2009–10). T7 also yielded the heaviest tubers per hill, while the lowest weight was observed in the control. Dry matter content ranged from 21.0% to 25.2%, with the highest in T7 and the lowest in T3.

The impact of integrated nutrient management (INM) on potato crops wasinvestigated[19] and reported that the highest tuber yield (32.71 t/ha) was achieved under N6 treatment, while the lowest (27.62 t/ha) was recorded under N4. The response of tuber yield per hill varied from 0.331 kg (N4) to 0.392 kg (N6). Similarly, N6 produced the maximum biological yield (46.59 t/ha) compared to the minimum (39.61 t/ha) in N4. These findings align with earlier studies by [20 & 21] and [22], which highlighted the positive impact of vermicompost and biofertilizers on potato yield.

The enhanced yields in N6 and N5 were attributed to the synergistic effect of combining inorganic fertilizers, organic manures, and biofertilizers, which improved soil properties and nutrient availability. Nutrient management practices also significantly influenced tuber grades. N6 recorded the highest number of total tubers per hill (10.15), including grades 'A' (2.37), 'B' (4.31), and 'C' (3.53), while N4 had the lowest values across these parameters.The study concluded that integrating 75% RDF with 8 t/ha vermicompost, Azotobacter, and PSB is a viable strategy for optimizing potato yields, particularly under the temperate conditions of the Kashmir Valley(Table 7).

Effect of INM on Soil Health

[12] reported that applying 20 t/ha of FYM along with chemical fertilizers significantly enhanced the levels of organic carbon (OC), nitrogen (N), phosphorus (P), potassium (K), zinc(Zn), iron(Fe), copper(Cu), and manganese (Mn) compared to treatments with either 10 t/ha of FYM or no manure (Table 8).

The impact of nutrient management practices on nutrient dynamics and sugarcane performancewas investigated by [13]. Their findings revealed that the Co 86032 (V2) variety recorded the highest soil nitrogen content (275.30 kg ha^{-1}). Among the different nutrient management treatments, N3 exhibited the highest soil nitrogen (332.52 kg ha^{-1}), while N7 recorded the lowest (142.77 kg ha^{-1}) (Table 9). This increase in soil nitrogen was attributed to the slow-release properties of organic manures, which enhanced residual soil fertility. However, soil phosphorus and potassium levels showed no significant variation due to the variety or nutrient management practices.

Conclusion

Integrated Nutrient Management (INM) is a sustainable and efficient strategy for improving crop productivity and maintaining soil health in cash crop systems. By combining organic and inorganic nutrient sources, INM enhances crop yields while supporting long-term soil fertility and protecting the environment. Future studies should emphasize the creation of region-specific INM strategies tailored to cash crops, advancing the production and quality of organic manures and biofertilizers, and raising farmer awareness about the enduring advantages of adopting INM practices.

Future scope of the study

Future research on INM should focus on region-specific nutrient strategies, long-term soil health sustainability, and enhanced biofertilizer efficiency. Precision agriculture and smart fertilizer applications can optimize nutrient use and reduce environmental impact.

Table 1: Effect of integrated nutrient management on plant height, number of monopodial and sympodial branches per plant and number of bolls per plant of Bt. Cotton at harvest

Treatments	Plant height (cm)			Number of monopodial (branches plant^{-1})			Number of sympodial (branches plant^{-1})			Number of bolls (bolls plant^{-1})		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
T1	106.23	111.03	108.63	3.91	3.21	3.56	16.00	17.00	16.50	33.00	34.00	33.50
T2	104.40	109.43	106.92	3.91	3.36	3.64	15.67	16.67	16.17	32.67	33.67	33.17
T3	101.50	105.53	103.52	3.96	3.35	3.66	15.00	16.33	15.67	31.00	32.67	31.83
T4	100.73	102.43	101.58	4.01	3.84	3.93	14.33	15.67	15.00	30.33	32.00	31.17
T5	112.87	113.17	113.02	3.92	3.51	3.71	16.67	17.33	17.00	34.67	35.67	35.17
T6	118.57	122.43	120.50	3.70	3.22	3.46	18.67	18.33	18.50	37.33	38.00	37.67
T7	121.87	125.80	123.83	3.63	3.06	3.34	19.67	19.33	19.50	39.33	40.00	39.67
T8	114.13	114.07	114.10	3.93	3.06	3.49	17.33	17.67	17.50	36.33	36.67	36.50
T9	130.73	128.73	129.73	3.19	3.67	3.43	20.00	20.33	20.17	40.87	41.17	41.02
T10	118.57	124.90	121.73	3.77	3.41	3.59	19.33	19.00	19.17	38.67	38.67	38.67
T11	116.07	120.83	118.45	3.72	3.28	3.50	18.00	18.67	18.33	36.33	38.00	37.17
T12	101.43	102.20	101.82	3.89	3.61	3.75	15.33	16.33	15.83	32.00	33.67	32.83
S.Em.±	6.27	6.20	4.41	0.36	0.25	0.22	1.02	0.94	0.69	2.30	1.94	1.50
C.D. at5%	18.38	18.18	12.57	NS	NS	NS	2.98	2.75	1.97	6.75	5.68	4.29
C.V.%	9.67	9.33	9.50	16.22	12.75	14.81	10.25	9.16	9.70	11.32	9.28	10.32

Source: [10]

Table 2: Effect of integrated nutrient management on boll weight, seed cotton yield, stalk yield and lint yield of Bt. Cotton

Treatments	Bollweight (g)			Seed cottonyield (kgha^{-1})			Stalkyield (kgha^{-1})			Lintyield (kgha^{-1})		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
T1	4.07	4.33	4.20	2501	2708	2604	4802	5165	4983	921	939	930
T2	4.05	4.18	4.12	2385	2589	2487	4640	5152	4896	879	893	886
T3	3.93	4.17	4.05	2107	2312	2210	4079	4079	4079	776	776	776
T4	3.83	3.97	3.90	1994	2196	2095	3827	3981	3904	735	732	734
T5	4.22	4.45	4.34	2414	2621	2518	5378	5311	5345	906	923	914
T6	4.71	4.62	4.67	2805	3004	2904	5707	5764	5736	1083	1074	1079
T7	4.93	4.96	4.94	2981	3187	3084	5912	5782	5847	1196	1180	1188
T8	4.32	4.47	4.39	2483	2691	2587	5496	5554	5525	939	956	948
T9	5.02	5.07	5.04	3014	3221	3118	6185	6112	6149	1229	1228	1229
T10	4.79	4.72	4.75	2857	3061	2959	5857	5779	5818	1105	1109	1107
T11	4.66	4.58	4.62	2746	2945	2846	5496	5645	5571	1054	1053	1053
T12	4.02	4.17	4.10	2453	2654	2554	4614	4807	4711	899	897	898
S.Em.±	0.28	0.22	0.18	158	166	115	453	392	300	50	55	37
C.D. at5%	0.81	0.65	0.50	465	487	327	1330	1149	855	146	161	106
C.V.%	10.89	8.54	9.76	10.71	10.40	10.56	15.2	12.90	14.08	8.83	9.71	9.28

Source: [10]

Table 3: Effect of integrated nutrient management on fibre yield of jute

Treatment (tonnes/ha)	Fibreyieldofjute			
	2004	2005	2006	Pooled
T_1,100%NPK	2.31	2.70	2.37	2.46
T_2,75%N throughurea+25%N throughWHC	2.69	2.96	2.23	2.63
T_3,75%Nthroughurea+25%N throughFYM	2.51	2.85	2.50	2.62
T_4,75%N throughurea+25%N through *dhaincha*greenmanure	2.56	2.73	2.40	2.57
T_5,75%Nthroughurea +25%Nthroughvermi- compost	2.60	2.83	2.12	2.48
T_6,50%N throughurea+50%N throughWHC	2.45	2.69	2.21	2.45
T_7,50%Nthroughurea+50%N throughFYM	2.53	2.69	2.43	2.55
T_8,50%N throughurea+50%N through *dhaincha*greenmanure	2.62	2.61	2.09	2.44
T_9,50%Nthroughurea +50%Nthroughvermi- compost	2.63	2.67	2.19	2.50
T_{10},control	1.36	1.42	1.53	1.44
SEm±	0.12	0.09	0.09	0.06
CD(P=0.05)	0.34	0.26	0.28	0.17

Source: [11]

Table 4: Effect of integrated use of FYM, inorganic sources of plant nutrients and bio-fertilizers on yield attributes, cane and sugar yield of spring sugarcane.

Treatments	No. of shoots at 150 DAS (thousand/ha)	Cane length (Cm)	Cane diameter (Cm)	Single cane weight (g)	Millable canes (thousand/ha)	Cane yield (t/ha)	CCS (t/ha)
FYM0+RDF50	113.7	182	2.32	961	84.1	71.0	9.3
FYM0+RDF100	120.4	184	2.24	1020	98.7	81.9	11.1
FYM0+ STB	125.6	190	2.31	1045	102.3	88.4	11.9
FYM20+RDF50	121.1	187	2.28	1000	101.2	80.1	10.8
FYM20+RDF100	133.4	197	2.28	1095	111.4	91.7	12.8
FYM20+ STB	142.2	198	2.25	1127	134.3	96.6	13.3
FYM10+BF+RDF50	121.7	185	2.27	1005	94.1	77.8	10.6
FYM10+BF+RDF100	133.5	192	2.30	1038	105.5	85.4	11.3
FYM10+BF+STB	135.9	194	2.31	1068	107.5	92.4	12.3
CD (P=0.05)	5.2	NS	NS	64.1	10.7	6.8	4.0

Source: [12]

Table 5: Sugarcane yield (t ha-1) as influenced by nutrient management practices in plantcrop ofsugarcane

NutrientManagementPractices (N)	Varieties		Mean
	V1-Co62175	V2- Co86032	
N1: Pressmud+sunnhemp +biofertilizers	135.31	118.95	127.13
N2:Pressmud+FYM+biofertilizers	133.83	118.52	126.17
N3:Pressmud +FYM+French beans + biofertilizers	137.35	126.69	132.02
N4:Pressmud +FYM +neem cake+biofertilizers	136.11	121.25	128.68
N5:Pressmud+FYM+vermicompost + biofertilizers	135.99	119.69	127.84
N6:50%Nthroughpressmud+50%Nthroughfertilizers+biofertilizers	187.94	152.72	170.33
N7:Recommendedpackageofpractices	191.65	157.99	174.82
N8: 100%NPKthrough fertilizersonly	137.04	124.63	130.83
Mean	149.40	130.05	-
	C.D. @ 5%	S.Em	
Varieties(V)	2.73	0.94	
Treatments (T)	5.02	1.73	
VxT	7.10	2.45	
TxV	7.18	2.48	

Source: [13]

Table 6: Effects of integrated nutrient management on yield attributes and yield of Potato.

Trt.	Plant height (cm)		Stems hill-1 (no)		Tubers per hill (no)		Weight of tubers per hill (kg)		(%) Dry matter by wt		Yield (t ha-1)	
	1 st yr	2 ndyr	1 st yr	2 ndyr	1 st yr	2 ndyr	1 st yr	2 ndyr	1 st yr	2 ndyr	1 st yr	2 ndyr
T1	5.0 d	43.0 e	4.98 c	4.68 d	5.25 e	5.00 e	0.28 c	0.27 d	22.5 bc	22.0 bc	14.1 d	13.8 e
T2	56.4 a	57.6 a	6.53 c	6.75 b	6.24 cd	7.17 cd	0.32 bc	0.35 ab	21.6 c	21.47 c	20.3 bc	21.4 c
T3	46.6 c	47.5 de	5.60 d	5.82 c	5.54 de	6.00 de	0.30 cd	0.31 bc	21.0 c	21.53 c	18.5 c	23.6 b
T4	52.6 b	54.8 a-c	6.87 bc	6.93 b	6.90 c	7.33 cd	0.32 bc	0.36 ab	22.0 bc	23.0 a-c	20.9 bc	22.5bc
T5	48.3 c	51.4 b-d	6.01 d	6.24 bc	7.88 b	8.83 ab	0.34 ab	0.38 a	22.9 ab	23.8 ab	22.3 b	23.6 b
T6	49.4 c	50.5 cd	7.18 b	6.93 b	7.00 bc	7.90 bc	0.33 bc	0.37 ab	22.5 a-c	23.5 ab	22.1 b	22.8 b
T7	54.2 ab	55.4 ab	7.69 a	7.84 a	8.87 a	9.50 a	0.37 a	0.40 a	23.3 a	24.2 a	25.2 a	26.4 a
CV (%)	6.58	5.00	4.40	7.41	7.98	5.57	7.79	10.0	3.20	4.00	6.58	4.00

Notes: T1= Control, T2= 100% RDF, T3= FP, T4= CD 6 t ha-1+70%RDF, T5= PM 3 t ha-1+70% RDF, T6= CD 6 t h-1+ rest from RDF and T7= PM 3 t ha-1+ rest from RDF. Figure(s) in a column having common letter(s) do not differ significantly.
Source: [14]

Table 7. Effect of integrated nutrient management on biological yield, harvestindex (%)andtuberyield of potato.

Treatment	Tuberyield		Biological	Harvest	Totaltubers	Numberoftubersperhill		
	t/ha	kg/plant	Yield (t/ha)	Index (%)	(No./hill)	Grade 'A'	Grade 'B'	Grade 'C'
N1	29.60	0.355	41.99	70.49	8.00	1.65	3.50	2.85
N2	30.21	0.363	42.83	70.52	8.61	1.85	3.68	3.10
N3	30.94	0.370	43.59	70.97	9.08	1.96	3.87	3.30
N4	27.62	0.331	39.61	69.68	7.23	1.55	3.10	2.50
N5	31.63	0.379	44.97	70.29	9.42	2.14	3.95	3.33
N6	32.71	0.392	46.59	70.29	10.15	2.37	4.31	3.53
SE(m)±	2.87	0.005	9.0	0.22	0.20	0.06	0.11	0.13
CD(0.05)	8.26	0.016	25.64	0.63	0.57	0.19	0.33	0.38

N_1=RDF (160:100:100NPKKg/ha);N_2=75%RDF+20t/haFYM;N_3=75%RDF+8t/ha VC;N_4= 75%RDF+AandPSB;N_5= 75%RDF+20 t/haFYM+Aand PSB; N_6 = 75% RDF+8 t/ha VC+A and PSB; RDF=recommended doses offertilizers; FYM = Farmyard manure; VC = vermicompost; A = Azotobacter;PSB= phosphorussolublizingbacteria.
Source: [19]

Table 8: Effect of INM and biofertilizers on chemical properties of the soil at harvest of sugarcane after 2 years

Treatments	pH	EC (ds/m)	OC (%)	$KMNO_4$- Avail. N	P	K	Zn	Fe	Mn	Cu
				mg/kg						
FYM0+RDF50	8.10	0.233	0.38	62.6	6.2	61.5	2.35	8.44	3.90	0.35
FYM0+RDF100	8.10	0.233	0.40	66.8	6.30	63.0	2.40	8.48	3.92	0.36
FYM0+ STB	8.10	0.235	0.41	67.3	6.30	64.4	2.45	8.48	3.92	0.36
FYM20+ RDF50	8.01	0.238	0.52	73.5	9.80	85.1	3.85	13.70	5.91	0.39
FYM20+ RDF100	8.01	0.245	0.54	76.3	9.90	88.1	3.90	13.60	5.95	0.39
FYM20+ STB	8.01	0.245	0.54	77.0	10.0	90.1	3.92	13.70	5.93	0.39
FYM10+BF+RDF50	8.04	0.242	0.48	70.2	8.40	79.9	3.12	10.80	4.86	0.38
FYM10+BF+RDF100	8.04	0.242	0.48	71.3	8.51	79.8	3.15	10.80	4.85	0.38
FYM10+BF+STB	8.04	0.242	0.48	72.0	8.51	79.5	3.15	10.80	4.85	0.38
Initial value	8.05	0.231	0.37	65.3	6.15	60.3	2.32	8.40	3.87	0.35
CD (P=0.05)	NS	NS	0.06	4.32	2.08	17.9	0.66	2.31	0.91	0.02

Source: [12]

Table 9: Soil available nitrogen, phosphorus and potassium (kg ha^{-1}) after harvest as influenced by nutrient management practices in plant crop of sugarcane.

Nutrient management practices (N)	Soil N		Mean	Soil P_2O_5		Mean	Soil K_2O		Mean
	Varieties			Varieties			Varieties		
	V1	V2		V1	V2		V1	V2	
N1 Pressmud+sunnhemp +biofertilizers	24.18	320.21	302.19	36.00	28.33	32.17	59.00	58.00	58.50
N2 Pressmud+FYM+biofertilizers	323.92	288.66	306.29	42.33	36.33	39.33	59.67	55.00	57.33
N3 Pressmud +FYM+French beans + biofertilizers	351.04	313.99	332.52	26.67	34.67	30.67	65.33	56.00	60.67
N4 Pressmud +FYM +neem cake+ Biofertilizers	294.73	254.22	274.48	35.33	32.67	34.00	59.33	55.00	57.17
N5 Pressmud+FYM+vermicompost + biofertilizers	221.24	316.10	268.67	24.67	32.33	28.50	60.33	64.00	62.17
N650%Nthroughpressmud+50%Nthrough fertilizers+biofertilizers	179.29	321.97	250.63	24.67	29.33	27.00	68.00	64.00	66.00
N7 Recommendedpackageofpractices	130.56	154.98	142.77	29.67	37.00	33.33	58.00	64.00	61.00
N8100%NPKthrough fertilizersonly	162.83	232.27	197.55	21.00	25.00	23.00	58.00	64.00	61.00
Mean	243.47	275.30	-	30.04	31.96	-	60.96	60.00	-
	S.Em ± C.D. @ 5%			S.Em ± C.D. @ 5%			S.E m ± C.D. @ 5%		
Varieties(V)	0.53 1.54			2.02 NS			2.09 NS		
NMP (N)	8.65 25.06			2.08 NS			2.58 NS		
V x N	12.23 35.44			2.94 8.51			3.65 NS		
N x V	11.45 33.18			3.41 9.88			4.01 NS		

V1 : Co 62175 V2 : Co 86032

Source: [13]

Reference

1. United Nations (2014). Department of Economics and Social Affairs, Population Division, World Population Prospects: The 2012 Revision, Methodology of United Nations and Projections, Estimates And Projections, Working Paper No. ESA/P/WP.235.

2. United States (2014). Census Bureauhttp:/www.census.gov/population/ international/ accessed on 11th April. 2014.

3. Rao, A.S., Lenka, N.K., Biswas, A.K. and Ramesh, K. (2015): Soil health enhancement- issues and strategies. Indian Journal of fertilizers 11(4):28-37.

4. Yadav, R. L., Prasad, S. R., & Singh, R. K. (2019). Integrated Nutrient Management for Sustainable Crop Production. Journal of Plant Nutrition, 42(4), 620-630.

5. Esilaba, A. O., Byalebeka, J. B., Delve, R. J., Okalebo, J. R., Ssenyange, D., Mbalule, M., et al. (2005). On farm testing of integrated nutrient management strategies in eastern Uganda. *Agr. Syst.* 86, 144–165. doi: 10.1016/j.agsy.2004.09.005.

6. Pathak, H., Aggarwal, P. K., and Roetter, R. P. (2011). Reducing the environmental impact of agriculture through improved nitrogen management. Agricultural Systems, 104(1), 30-40.

7. Sharma, K. L., Mandal, U. K., Srinivas, K., and Vittal, K. P. R. (2015). Long-term effect of integrated nutrient management on soil properties and crop yields in rice-wheat system in a semi-arid environment. Soil and Tillage Research, 91(2), 123-130.

8. Prasad, R., Power, J. F., andJuo, A. S. R. (2012). Managing Fertilizers for Sustainable Agriculture. Nutrient Cycling in Agroecosystems, 63(1), 9-20.

9. Vessey, J. K. (2003). Plant growth promoting rhizobacteria as biofertilizers. Plant and Soil, 255(2), 571-586.

10. Parmar, R.M., Parmar, K.B. and Jadeja,A.S.(2019). Effect of integrated nutrient management on yield and yield attributing characters of *Bt.*Cotton (*Gossypiumhirsutum*L.) undernorth–westagroclimaticzoneof Gujarat *International JournalofChemical Studies;7(1):2362.*

11. Mitra, S., Roy, A., Saha, A. R., Maitra, D. N., Sinha, M. K., Mahapatra,B. S. and Saha,S. (2010). Effect ofintegrated nutrient management on fibre yield, nutrient uptake and soil fertility in jute (*Corchorusolitorius*)*Indian Journal of Agricultural Sciences,*80 (9): 801–804.

12. Pal, R., Singh, O., Sanghera, G. S. and Gupta, R. K. (2021). Influence of INM on sugarcane productivity and soil fertility under Indo-Gangetic plain *Indian Journal of Agricultural Sciences* 91(5): 703–7.

13. Keshavaiha, V., Palled, Y.B., Shankaraihah, C., Channal, H. T., Nandihalli,B. S. and Jagdeesha,K. S. (2012). Effect of nutrient management practices on nutrient dynamics and performance of sugarcane *KarnatakaJ.Agric. Sci.,25 (2):187-192.*

14. Islam,M., Akhter,S., Majid,N.M.,Ferdous,J.,Alam,M. S. (2013).Integrated nutrient management for potato (*Solanum tuberosum*) in grey terrace soil. *Australian journal of crop science.7(9):1235-1241.*

15. Noor, S., Shil, N.C., Sultana, S. and Farid, A.T. M. (2005). Evaluation of some organic manure on the yield of cabbage under integrated nutrient management system. Bangladesh J Agric Environ 1: 53-59.

16. Mondal, S. S., Acharya, D., Ghosh, A. and Bug, A. (2005). Integrated nutrient management on the growth, productivity and quality of potato in Indo-Gangetic plains of West Bengal. Potato J 32: 75-78.

17. Thind, S. S., Sidhu, A. S., Sekhon, N. K.and Hira, G. S. (2007). Integrated nutrient management for sustainable crop production in potato-sunflower sequence. J Sustai.Agr. 29: 173-188.

18. Baishya, L. K., Kumar, M. and Ghosh, D. C. (2010). Effect of different portion of organic and inorganic nutrients on productivity and profitability of potato (Solanum tuberosum) varieties in Meghalaya hills. Indian J Agron 55: 230-234.

19. Narayan, S., Kanth, R. H., Narayan, R., Khan, F. A., Singh,P.and Rehman,S. U. (2013). Effect of integrated nutrient management practices on yield of potato.Potato J. 40 (1): 84-86.

20. Kumar, V., Jaiswal, R. C. and Singh, A. P. (2001). Effect of biofertilizers on growth and yield of potato. J Indian potato Assoc 28: 6-7.

21. Kumar, M., Baishya, L. K., Ghosh, D. C. and Gupta, V. K. (2011). Yield and quality of potato (Solanum tuberosum) tubers as influenced by nutrients sources under rained conditions of Meghalaya. Indian J Agron 56(3): 260-66.

22. Mohapatra, B. K., Maiti, S. and Satapathy, M. R. (2008). Integrated nutrient management in potato (Solanum tubnerosum)–Jute (Corchorus olitorius) sequence. Indian J Agron 53 (3): 205-09.