



Integrated Nitrogen Management in Growth and Yield of Chilli (*Capsicum annum* L.) Under Red and Lateritic Soils of Odisha

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Authors' contributions

This work was carried out in collaboration among all authors. Author GHS designed the study and wrote the first draft of the manuscript. Authors GS and PPP supervised the study and analyzed the data. Authors SB and PPP managed the literature search writing of the final manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i1230349

Editor(s):

(1) Marco Trevisan, Catholic University of the Sacred Heart, Italy.

Reviewers:

(1) Sami Ali Metwally, National Research Centre, Egypt.

(2) Rafid Abdulwahid Abdulkareem, University of Baghdad, Iraq.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/61195>

Original Research Article

Received 02 July 2020
Accepted 09 September 2020
Published 17 September 2020

ABSTRACT

The present study was conducted in research plots of Central Horticultural Research station (CHES) during *Rabi* season 2018-2019 on Integrated Nitrogen management in chilli under lateritic soils of Odisha. The field experiment was laid out in Randomized Block Design comprising of eight treatments replicated thrice. It was observed that the substitution of N through vermicompost to the extent of 50% and remaining 50% as urea proved to be considered as the best treatment amongst different combinations of organic sources with urea (RDF). The highest yield of chilli i.e. both pod yield (14511.4 kg ha⁻¹) and stover yield (901.05 kg ha⁻¹) and plant growth such as plant height, flowering, fruiting, fruit length, fruit girth was observed in T₅ due to combination of 50% of N as urea and 50% of N as VC. Integrated use of organic manures along with chemical fertilizers not only produced highest and sustainable crop yields but also enhanced plant growth due to quick mineralization and easy availability.

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Keywords: Integrated nitrogen management; urea; vermicompost; FYM; chilli.

1. INTRODUCTION

Chilli (*Capsicum annuum* L.) belongs to family Solanaceae and is one of the important vegetable crops for agricultural economy and processing industries. The current global scenario depicts India as the largest producer, consumer as well as exporter of chilli, which contribute about 25 per cent of total world's production [1]. Chilli production in India is estimated to cover an area of 366 thousand ha with production of 3737 thousand tones. Among states, Andhra Pradesh (30%) is the largest producer of chilli in India, followed by Karnataka (20%), Maharashtra (15%), Orissa (9%), Tamil Nadu (8%) and other states contributing around 18 per cent of the total area under chilli production [2]. It is an integral intergradient in most cuisines around the world as it adds pungency, taste, flavor and colour to the dishes and hence named as 'wonder spice' [3]. The deficiency of plant nutrients causes different changes in the physiological and biochemical processes within the plant cell resulting a delay in development and reduction in growth as well as yield [4,5]. Recently a noticeable decline in productivity of many intensively cultivated areas might be attributed to soil degradation through nutrient depletion and loss of soil quality due to continuous as well as injudicious use of inorganic fertilizers. Thus, integrated nutrient management system aims at maintenance of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner [6]. This in turn would reduce wastage of resources and promote environmental stewardship.

Nitrogen (N) is the key element among the major nutrients in crop production and most of the Indian soils are deficient in N. Most of the N in plough layer of arable soils is present in a continuum of complex organic forms [7]. To supply N to crops, a dynamic equilibrium between mineralization and immobilization processes operates in soil system through biological transformation of applied N sources [8]. It showed that the highest yield of chilli was observed in INM treatment receiving N from vermicompost and 50 per cent urea as well as qualitative traits were improved with the application of neem cake compared to other inorganic sources [9]. In a study, combined application of 150 kg N ha⁻¹ along with 10 t ha⁻¹

FYM and 0.5 t ha⁻¹ neem cake improved the yield and quality of chilli [1]. It was reported that the application of 50 per cent RDF in combination with vermicompost at 5 t ha⁻¹ resulted in highest growth and yield of brinjal [10]. It was also reported that application of 50% NPK + 50% FYM + bio fertilizers (Azospirillum and Phosphotika) significantly increased the growth and yield of chilli than sole inorganic treatments [5]. Such studies also revealed that INM treatments were more economical with higher net returns and benefit cost ratio than the sole application of either inorganic or organic nutrients. With this research background, the present study has been planned that aims at assessing effects of various organic and inorganic sources of nitrogen on yield and growth attributes on chilli under integrated nitrogen management system in red and lateritic soils of Odisha.

2. MATERIALS AND METHODS

The experiment was laid out in dominant acid soil regions of the Central Horticultural Research Station (CHES) with chilli crop (Arka Harita cultivar) during Rabi season 2018-19 following Randomized Block Design with 8 treatments and 3 replications with experimental plot size 0.6m x 0.6 m. The soil of the experimental plot was sandy loam in texture having 77.5% sand, 11.0% silt and 11.5% clay, acidic (pH 4.5) in nature, low in organic carbon (3.34 kg ha⁻¹) and available phosphorus (7.77 kg ha⁻¹), medium in available nitrogen (284 kg ha⁻¹) and available potassium (129 kg ha⁻¹) (Table 1). Land preparation, levelling, demarcation etc. were done prior to transplanting. Seedling treatment were done with Bavistin and Chloro dust were applied @ 50 kg ha⁻¹ against treatment. The treatment details of the trial consisted of T1-control (no nitrogen), T2- 100% of N through RDF, T3- 50% of N through RDF +50% of N through Farm Yard Manure (FYM), T4- 25% of N through RDF + 75% of N through FYM, T5- 50%(NPK) + 50% (Vermicompost), T6- 25%(NPK) +75%(VC), T7- 100%N(FYM), T8- 100%N (VC) were laid out in randomized block design with three replications. The plant nutrients were applied through fertilizer viz., urea, single super phosphate and muriate of potash for N, P and K respectively. Full dose of P₂O₅ and K₂O was applied to all the treatments as basal including control plot FYM and vermicompost was applied as per treatment combination and calculated on the basis of

Table 1. Physico-chemical properties of the soil in experimental site

Sl. No.	Particulars	Values obtained	Method adopted
I	Physical properties		
1.	Particle analysis		Hydrometer method
a.	Sand (%)	62.4	} Sandy loam
b.	Silt (%)	25.2	
c.	Clay (%)	12.4	
2.	W.H.C (%)	36.13	
3.	Porosity (%)	51.5	
4.	Particle density ($M\text{-g m}^{-3}$)	2.45	
5.	Bulk density ($M\text{-g m}^{-3}$)	1.11	
II	Chemical properties		
1.	Soil pH (1:2: soil: water)	4.35	pH meter
2.	Electrical conductivity ($dS\text{ m}^{-1}$)	0.11	Conductivity bridge (Systronics Model-304)
3.	Organic carbon (%)	0.32	Wet digestion method by Walkley and Black method
III.	Available nutrients		
1.	Available nitrogen ($kg\text{ ha}^{-1}$)	160	Alkaline permanganate method
2.	Available phosphorus ($kg\text{ ha}^{-1}$)	15.92	Bray's No.1 method
3.	Available potassium ($kg\text{ ha}^{-1}$)	72	Flame photometer
4.	Available sulphur ($kg\text{ ha}^{-1}$)	11.23	Soxhlet extraction method

nutrient content. The full dose of Nitrogen was applied in 3 equal splits to each treatment except control plot. The soil samples of the experimental plots were dried under shade, crushed, sieved through 2 mm sieve and were analyzed for different physical and chemical properties as per the following the standard methods [11].

Pods were harvested at maturity i.e. green matured chilli and the pod yield obtained after each harvesting and straw yield after uprooting of crop was recorded with fresh as well as dry stover yield. Yield obtained in gm per plot was expressed as $kg\text{ ha}^{-1}$. For recording growth attributing parameters biometric observations of five plants from each treatment were randomly selected, then the selected plants were labelled with proper notations for recording the observations on the growth and yield parameters for the different treatment plots. Plant height was recorded from selected plant and then the average was worked out. Height of plant was measured in centimeters from the ground level to the tip of fully opened leaf with the help of meter scales at the time of last harvest. The number of first order branches arising on main shoot were referred to as primary branches and were counted on the tagged plants and average primary branches were found out and expressed in number. At each picking number of fruits collected from each treatment plot were

recorded. After the final picking sum of all fruits from all pickings were added and thus total number of fruits from each plot was calculated. Length of the five mature fruits at fully matured stage was measured individually in centimeters from the base of pedicel to the tip of the fruit and average was worked out and expressed in centimeters. Fruit width was measured by using Vernier calipers and average was worked out and expressed in centimeters. The experimental data pertaining yield and growth parameters were recorded, compiled in appropriate Tables and analyzed statistically as per the procedure appropriate to the design [12,13].

3. RESULTS AND DISCUSSION

In chilli field applied nitrogen in form of both organic and inorganic fertilizer undergoes different biochemical reaction so that nitrogen is available to the chilli plant in adequate amount and appropriate time. Nitrogen loss is more from the inorganic source in form of volatilization, percolation, leaching loss etc. as compared to that of organic source. In order to check the losses and increase the nitrogen use efficiency inorganic form of nitrogen is used along with organic sources of nitrogen. To enhance the yield in case of chilli crop both organic and inorganic source of nitrogen was used that help in quick mineralization and easy uptake by plants and maintaining soil health.

Table 2. Effect of different combination source of nitrogen on yield attributing characteristics of chilli

Treatment Details	1st Flowering (days)	50 % flowering (days)	1st fruiting (days)	Plant height (cm)	Stem thickness (cm)	Primary branches (no.)	Fruit length (cm)	Fruit girth (cm)
T ₁ - Control	57.00	63.00	60.00	47.33	2.70	3	7.03	2.69
T ₂ - RDF (NPK) 100%	54.00	58.00	58.00	60.67	3.65	5	8.45	3.27
T ₃ - 50% RDF+50% N through FYM	54.00	58.00	58.00	60.18	3.56	5	8.15	3.28
T ₄ - 25% RDF+75% N through FYM	55.00	61.00	59.00	58.89	3.43	4	8.62	3.29
T ₅ - 50% RDF+ 50% N through VC	53.00	58.00	58.00	63.33	3.71	7	9.21	3.44
T ₆ - 25% RDF+75% N through VC	55.00	60.00	58.00	60.07	3.54	4	8.80	3.36
T ₇ - 100% N through FYM	56.00	62.00	60.00	51.38	2.85	5	7.90	3.17
T ₈ - 100% N through VC	56.00	62.00	60.00	55.11	2.96	6	8.13	3.22
S. Em (±)	0.44	0.99	1.60	21.37	0.20	0.32	0.34	0.15
C.D.(p=0.05)	1.35	3.01	4.85	6.99	0.61	0.99	1.04	0.47

3.1 Effect of Different Combination Source of Nitrogen on Growth Attributing Characteristics of Chilli

The growth attributing characteristics of chilli were presented in Table 2. Number of days to 1st flowering was observed to be lowest in case of T₅ (50% RDF+ 50% N through VC) i.e. 53 days and highest in case of T₁ (no nitrogen) i.e. 57 days. The mineralization in case T₂ was highest due to application of 100% nitrogen in form of urea where mineralization was highest and uptake of nitrogen by plant was optimum. Nitrogen influences the vegetative characteristics of chilli crop. In case of T₅ where integrated application of nitrogen was done through urea and vermicompost, the days to flowering about 1 day less than in T₂ (RDF 100%). The mineralization rate of nitrogen was more as compared to urea in case of integrated application. With application of completely organic fertilizers in T₇ (100% N through FYM) and T₈ (100% N through VC), release of nitrogen and uptake was comparatively less during its vegetative growth. Nitrogen gets easily available in case of vermicompost than that of FYM. This finding is also in confirmation with the result [14,15].

Integrated nitrogen management showed that number of days to 50% flowering was 58 days in case of T₅ (50% RDF+ 50% N through VC) whereas in case of T₁ (No Nitrogen) it was observed to be more. A combination of 50% VC and 50% urea yielded better result than that of T₂ (RDF 100%) or T₈ (100% N through VC) and T₇ (100% N through FYM). Application of only organic source of nitrogen through i.e. FYM and VC could restore soil health but mineralization of N was observed to be less due to higher C: N

ratio. Uptake was optimum and in appropriate duration for 50% flowering in chilli crops. This finding was also in corroboration with the result [14,16].

Increase in growth attributing characters such as plant height, days to 1st fruiting, number of primary branches, stem thickness, fruit length and fruit diameter was due to 50% application of N through urea and vermicompost respectively. This enhanced the uptake and mineralization of nitrogen influencing the vegetative characters of the chilli crop. Here the observation recorded was as follows T₅(50% RDF+ 50% N through VC) > T₂(RDF 100%)> T₃ (50% RDF + 50% N through FYM) > T₆ (25% RDF+ 75% N through VC) > T₄ (25% RDF+ 75% N through FYM) > T₆ (25% RDF+ 75% N through VC) > T₄ (25% RDF+ 75% N through FYM) >T₈ (100% N through VC) >T₇ (100% N through FYM) . This results also confirms with the findings of [2].

3.2 Effect of Different Combination Source of N on Yield of Chilli

The grain and straw yield of chilli and its harvest index were presented in Table 3. The increase in chilli pod was 8% due to application 50% N through Urea and 50% of Nitrogen VC whereas there in increase 29% was recorded from application 100% of N through VC to that of T₅ (50% RDF+ 50% N through VC). It might be due to integrated application of nitrogen in both organic and inorganic form. The chilli pod yield was measured to be 14511.4 kg/m in T₅ (50% RDF+ 50% N through VC) which was statically at par to T₂ (100% RDF). Basing on this observation nitrogen dose through organic and inorganic sources has helped in enhancing yield.

Table 3. Effect of different combination source of nitrogen on yield of chilli

Treatment details	Number of fruits (plant ⁻¹)	Yield (g plant ⁻¹)	Yield (kg ha ⁻¹)	Yield dry wt. (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)
T ₁ . Control	39.00	167.70	6204.9	4591.67	183.53	0.92
T ₂ . RDF (NPK) 100%	72.00	361.90	13390.9	10043.33	476.30	0.96
T ₃ . 50% RDF+50%N through FYM	70.00	323.20	11958.4	9328.00	661.45	0.94
T ₄ . 25% RDF+75% N through FYM	67.00	305.00	11285.0	8248.67	517.69	0.94
T ₅ . 50% RDF+ 50% N through VC	74.00	392.20	14511.4	11476.00	901.05	0.97
T ₆ . 25% RDF+75% N through VC	71.00	312.47	11561.3	9069.00	868.28	0.95
T ₇ . 100% N through FYM	61.00	250.10	9253.7	7123.33	497.61	0.94
T ₈ . 100% N through VC	62.00	276.07	10214.4	7826.33	520.98	0.93
S. Em (±)	-	12.275	454.165	217.76	8.99	-
C.D.(p=0.05)	-	37.235	1377.703	824.40	27.29	-

Even conjoint application of VC or FYM with RDF has significantly higher yield than simple application of organic source of N through VC and FYM. Similar finding was reported by Chouhan et al., (2015) and Kapse., (2016). Number of fruits per plant and their weight followed same trend causing same effects. Harvest index of chilli followed the same trend as that of chilli yield. This finding is also in confirmation with the result of [15,16].

4. CONCLUSION

Present investigation was conducted to study the effect of integrated nitrogen management on growth attributing characters and yield of chilli crop. Conclusions of this investigation showed that, the growth attributing characters of chilli plant was higher in case of conjoint application of 50% N through VC+ 50% through RDF. Highest chilli yield was recorded due combined application of 50% N through VC+ 50% through RDF which was statistically at par with 100% RDF. Application of nutrients in combinations have a significant and vital effect on yield and growth attribute characters of chilli. The supply of various plant nutrients at an optimum level sustains the desired crop productivity by optimizing the benefit from all sources in an integrated manner. The inference drawn from the present investigation clearly stated that organics are effective alternatives for nitrogen management and have a potential to improve yield and growth parameters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:
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