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Integrated Nitrogen Management in Yield, Uptake and Quality Parameters of Chilli (*Capsicum annum* L.) under Red 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.

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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 red lateritic soils of Odisha to study the effect of different combination of nitrogen sources on yield, uptake, quality parameters and economics on chilli crop. 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 uptake of nitrogen by pod (122.31 kg ha^{-1}) and stover (8.72 kg ha^{-1}) were observed in T_5 due to combination of 50% of N as urea and 50% of N as VC. The highest B: C ratio was found to be highest in T_2 (100% of N through RDF). Regarding the quality parameters of chilli like oleoresin, capsaicin, ascorbic acid

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and protein content were also found highest in T_5. Integrated use of organic manures along with chemical fertilizers not only produced highest and sustainable crop yields but also enhanced the efficiency of added fertilizers.

Keywords: Yield; uptake; urea; vermicompost; FYM; chilli.

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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 tonnes. It is cultivated on 70,000-80,000 hectares in Odisha [2]. It is called as the universal spice of India, since it is cultivated in almost all the states and union territories. In India, area under chilli is about 774.87 thousand hectare and production 1492.14 thousand MT with productivity of 1.9 thousand MT per hectare [2]. Sambalpur and Ganjam districts are the major chilli producing areas, though a sizeable number of farmers grow the crop in Jharsuguda, Balangir, Koraput and Puri districts of Odisha. It is an integral inter gradient in most cuisines around the world as it adds pungency, taste, flavor and colour to the dishes and hence named as 'wonder spice'. It has a rich source of protein, vitamin C (ascorbic acid), pigments (capsanthin) and alkaloid (capsaicin). 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 [1]. 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 [2]. To supply N to crops, a dynamic equilibrium between mineralization and immobilization processes operates in soil system through biological transformation of applied N source. It was observed 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 [3]. 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.

Adequate and balanced fertilizer management in association with manures is very much essential to exploit the full yield potential of Chilli. After the green revolution, increase in production was achieved at the cost of soil health. It has been proved that indiscriminate use of inorganic fertilizers results in decrease in soil fertility and increase in soil acidity with depletion of organic humus content in addition to poor crop quality. Use of organic manures to meet the nutrient requirements of crop would be an inevitable practice in the years to come for sustainable agriculture since organic manures not only improve the physical, chemical and biological properties of soil [3]. Chilli crop requires a balanced fertilizer management without which growth and development of the crop will be impaired leading to substantial reduction in yield of the chilli. Organic matter like farm yard manure, vermicompost, poultry manure and crop residues are considered as a store house of various nutrients which are essential for the plant growth. Use of organic manures alone cannot fulfil the crop nutrients requirement. Mixture of organic manures and inorganic fertilizers gave better results than organic manure alone [2]. The integrated supply and use of plant nutrients from chemical fertilizers and organic manures has shown to produce higher crop yields than when they are applied alone. Use of judicious combinations of organic and inorganic fertilizer sources is essential not only to maintain the soil health but also sustain the productivity [3]. Hence, the present investigation was carried out to find out assessing effects of various organic and inorganic sources of nitrogen on yield, N uptake, quality parameters and to compute the cost economics under integrated nitrogen management system.

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}). 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 T_1-control (no nitrogen), T_2-100% of N through RDF, T_3- 50% of N through RDF +50% of N through Farm Yard Manure (FYM),T_4- 25% of N through RDF + 75% of N through FYM, T_5- 50% (NPK) + 50% (Vermicompost), T_6- 25% (NPK) +75%(VC), T_7-100% N(FYM), T_8- 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 P_2O_5 and K_2O 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 nutrient content. The full dose of Nitrogen was applied in 3 equal splits to each treatment except control plot.

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 $hectare^{-1}$. The soil samples of the experimental plots were analyzed for different physical and chemical properties as per the following the standard methods. Five plants from each treatment were selected randomly. After washing with distilled water and the samples were dried in the hot air oven at a temperature of 60°C. The plant sample were processed and used for analysis. The fruits were collected from each treatment and fresh fruit sample was taken for nutrient analysis. The soil was analyzed in the laboratory following standard procedures. Available N in soil was determined by modified alkaline permanganate method [4]. The plant samples were digested with conc. H_2SO_4 and the total nitrogen content was determined by using Pelican make Distyl Em distillation unit [5]. The samples were pre-digested in di-acid mixture [HNO_3: $HClO_4$ (3:2)]. The experimental data pertaining to nutrient uptake, yield was recorded, compiled in appropriate tables and analyzed statistically by the technique of analysis of variance as applicable to randomized block design given by Panse and Sukhatme [6,7].

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.

3.1 Effect of Different Combination of N Sources on Yield and Uptake of Chilli

The data pertaining pod and stover yield of chilli as influenced by different treatments are presented in Table 1. The application of different sources of organic manures and their combination on chilli significantly influenced the yield of green chilli as well as stover. The increase in chilli pod yield 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 T_5 (50% RDF+ 50% N through VC). It might be due to integrated application of nitrogen in both organic and inorganic form. The highest chilli pod yield was measured to be 14511.4 kg ha^{-1} in T_5 (50% RDF+ 50% N through VC) which was statically at par to T_2 (100% RDF) i.e. 13390.9 kg ha^{-1}. Basing on this observation nitrogen dose through organic and inorganic sources has helped in enhancing yield. Similarly, highest stover yield was found to be 901.05 kg ha^{-1} in T_5 (50% RDF+ 50% N through VC) followed by T_6 (868.28 kg ha^{-1}) which was treated with 25% RDF+ 75% N through VC. 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 findings were reported by [8,9].

Table 1. Effect of different combination of nitrogen sources on yield and uptake of chilli

Treatment	Pod Yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Nitrogen uptake (kg ha^{-1})		
			Pod	Stover	Total
T_1 - Control	6204.9	183.53	55.44	1.25	56.69
T_2 - 100% RDF(NPK)	13390.9	476.30	111.49	3.77	115.26
T_3- 50%RDF+50%N through FYM	11958.4	661.45	94.55	6.20	100.75
T_4 - 25%RDF+75%N through FYM	11285.0	517.69	84.81	5.42	90.23
T_5 - 50% RDF+ 50% N through VC	14511.4	901.05	122.31	8.72	131.03
T_6 - 25%RDF+75% N through VC	11561.3	868.28	97.03	8.17	105.2
T_7 - 100% N through FYM	9253.7	497.61	79.39	4.90	84.29
T_8 - 100% N through VC	10214.4	520.98	84.19	4.81	89
S. Em (±)	454.165	8.99	2.99	0.11	2.93
C.D.(p=0.05)	1377.703	27.29	9.08	0.34	8.89

The data pertaining to the uptake of nutrients by chilli pod, stover and total nutrient uptake by chilli crop as influenced by different treatments due to application of different sources of organic manures and their combination on chilli are presented in Table 1. Nitrogen uptake by chilli pod and stover and total uptake was increased with integrated application of N through both organic and inorganic source (Table 1) due to more availability of N for plant utilization which increases the N uptake on the other hand the pods and stover yield increased due to application of higher doses of N which indirectly increases the total N uptake by chilli crop. The N uptake by chilli crop by pod and stover due to application of VC or FYM with urea was higher than that of urea might be due to availability of more nitrogen for longer period due to higher C: N of VC and FYM and easy mineralization of urea. It was observed from the data that the uptake of nitrogen in the stover ranged from 1.25 to 8.72 kg ha^{-1} due to effect of various treatments and it was found statistically significant. The maximum stover uptake (8.72 kg ha^{-1}) was recorded by the treatment T_5 receiving 50% N through VC and 50% RDF, which was found to be statistically at par with T_6 i.e. 8.17 kg ha^{-1}. Similarly, the uptake of nitrogen by pod ranged from 55.44 to 122.31 kg ha^{-1} and the highest uptake of nitrogen by pod is found 122.31 kg ha^{-1} T_5 followed by T_2 111.49 kg ha^{-1} which was treated with 100% RDF. The total nitrogen uptake was found highest in T_5 (131.03 kg ha^{-1}) followed by T_2 (115.26 kg ha^{-1}). Minimum uptake in case of pod, stover and total uptake was recorded in control [10]. When the organics were added to soil, even though the initial available nitrogen content was low, the complex nitrogenous compounds slowly break down and make steady N supply throughout the growth period of the crop. This might have attributed to more availability and subsequent uptake by the crop, thus increasing the yield.

3.2 Effects of Different Combination of Nitrogen Sources on Quality Parameters of Chilli

Concentration of Oleoresin, ascorbic acid, capsicum, and protein in chilli were recorded to be highest in case of T_5 i.e. (50% RDF + 50% VC) which is represented in Table 2. The use of organic manures corrects multiple deficiency and sectional elements improve physical, chemical and biological properties of plants. It influences and improves the quality parameters due to conjoint application of VC and urea. With application of 100% N through RDF proved to yield, quality parameter comparative lower than T_5. In case of application of 100% N through FYM and 100% N through VC i.e. T_7 and T_8 the values for quality parameter was lower than their interaction with urea. The highest oleoresin content was highest in T_5 (11.96%) which significantly at par with T_3 (11.93%). The capsaicin content (%) and ascorbic acid content (mg/100g) of chilli differed significantly by adopting different nutrient management practices and application of organic amendments. Significantly, the highest values were observed in T_5 and the lowest value in control. Interaction effects were also proved to be highly significant [11,12]. They reported significantly higher ascorbic acid content with the application of organics. Similarly, in case of protein content the highest value was found in T5 (50% RDF+ 50% N through VC) i.e 72.10 mg/100g followed by T3 (50%RDF+50%N through FYM) i.e. 65.32 mg/100g. This report was also similar to the finding by [13,14].

Table 2. Effect of different combination of nitrogen sources on quality parameters of chilli

Treatment	Oleoresin (%)	Capsaicin (%)	Ascorbic acid (mg/100 g)	Protein (mg/100 g)
T_1 - Control	8.17	38.68	33.98	38.68
T_2 - 100% RDF(NPK)	11.02	60.86	62.4	60.86
T_3- 50%RDF+50%N through FYM	11.93	65.32	72.73	65.32
T_4 - 25%RDF+75%N through FYM	9.47	57.69	57.35	57.69
T_5 - 50% RDF+ 50% N through VC	11.96	72.10	73.48	72.10
T_6 - 25%RDF+75% N through VC	11.38	59.32	63.32	59.32
T_7 - 100%N through FYM	11.09	50.57	43.07	50.57
T_8 - 100% N through VC	9.90	55.46	56.24	55.46
S. Em (±)	0.19	0.37	0.32	0.37
C.D.(p=0.05)	0.59	1.14	0.98	1.14

Table 3. Effect of different combination of nitrogen sources on Economics of chilli

Treatment	Cost of cultivation	Gross income	B:C ratio
T_1 – Control	70000.00	155122.5	2.09
T_2 - 100% RDF(NPK)	71602.00	334773.00	4.67
T_3- 50%RDF+50%N through FYM	90801.00	298960.00	3.29
T_4 - 25%RDF+75%N through FYM	100400.00	282125.00	2.81
T_5 - 50% RDF+ 50% N through VC	93876. 00	362785.00	3.86
T_6 - 25%RDF+75% N through VC	105015.00	289031.5	2.75
T_7 - 100%N through FYM	110000. 00	231342.5	2.19
T_8 - 100% N through VC	116150 .00	255361.75	2.21

3.3 Economics of Chilli Crop

The highest cost of cultivation, gross income and B:C ratio (presented in Table 3) was observed with T_2 (RDF 100%) plot which might be due to addition of more input as well as more economic produces because of more N available for plant utilization. Presence of 50% VC and 50% FYM with 50% Urea yield comparatively less result than T_2 (RDF 100%) due to cost sense of VC and FYM and yield of T_2 being at par with T_5. The highest B:C ratio of 4.67 was observed with T_5 indicating that farmer will get 4.67 of the expenditure is Rs 1.00. This result corroborates the finding of [15].

4. CONCLUSION

Present investigation was conducted to study the effect of integrated nitrogen management on yield attributing, yield and economics of chilli crop. Conclusions of this investigation are depicted below. The quality parameter 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. Nitrogen uptake was more in integrated nitrogen applied plot than that of solo application of nitrogen. Benefit cost ratio of was highest due to application of 100% RDF than that of combined application of VC or FYM with urea. Thus, it may be concluded that integrated nitrogen management practice was found beneficial for sustaining soil health in terms of buildup of organic carbon and enhancing the crop yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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