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Nitrogen management in okra through neem coated urea

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Abstract

A two-year investigation was carried out to examine the effect of nitrogen on growth and yield of okra with fourteen treatments containing different combinations of organic (vermicompost and farm yard manure) and inorganic (urea and neem coated urea) sources of nitrogen replicated thrice at Vegetable Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand in summer seasons of year 2016 and 2017. Observations for plant height, stem diameter, per plant number of leaves, primary branches and nodes at 45 days after sowing (DAS), leaf area at 60 DAS, green pod length and diameter, average weight of green pod, number of green pods and green pod yield plant^{-1} were recorded. The findings revealed that among all others, treatments T_{10} (Recommended dose of nitrogen, RDN- 100% through neem coated urea + 2.5 t ha^{-1} vermicompost) and T_6 (RDN- 75% through neem coated urea + 25% through vermicompost) were found best with respect to improvement in plant growth and yield characters. The highest number and yield of green pods per plant were recorded under treatments T_6 (25.8 and 293.3 g plant^{-1}) and T_{10} (23.3 and 294.7 g plant^{-1}) as compared to other treatments. Hence, it can be concluded that application of neem coated urea along with vermicompost could be recommended for obtaining higher yield of okra in summer season under lowland regions of India.

Keywords: Okra; Neem coated urea; Vermicompost; FYM; Growth; Yield

Introduction

Okra [*Abelmoshcus esculentus* (L.) Moench] is a well-known annual vegetable crop of tropic and sub-tropic regions of world, valued for its economic importance because of its high nutritional value that has potential to improve food security. India ranks first (61.9%) followed by Nigeria and Sudan among major okra producing countries in the world. In the year 2017-18, okra in India, occupied an area of 0.51 million ha with total production 6.1 million ton (t) and productivity of 11.98 t ha^{-1} which includes both the seasons of crop (Ministry of Agriculture and Farmers Welfare 2018). It accounts for 4.96% of total vegetable area and 3.30% of total vegetable production in India. In Uttarakhand, it occupies an area of 3.62 thousand hectares with total production of 26.10 thousand ton and productivity 7.21 t ha^{-1}. This shows that there is still a wide gap in its production capacity as compared to national productivity, even when okra is grown in two seasons in a year in this state. It may be due to the long-term indiscriminate use of fertilizers due to which a continuous decline in soil fertility has been evolved that have caused a continuous decline in its proper yield potential.

Nitrogen (N) a macro-nutrient is regarded as the most critical nutrient required for adequate nutrition and high yield of okra. It contributes to the plant growth characters and in general found to be directly correlated with yield and quality parameters. Because of nitrification and leaching losses, low levels of available soil N and organic matter content accounts to a widespread N deficiency in India. The production capacity of soil has reduced due to imbalanced use of nitrogenous fertilizers (especially Urea) for obtaining greater yields. As an effective natural way to reduce such losses, the application of neem coated urea (NCU) and organic manures in combinations have been proved to be the best. Farm yard manure (FYM) and vermicompost (VC) are the two organic sources of nitrogen that are mainly popular among the farmers in India. There are many literatures available on the use of these organic sources for cultivation of vegetable crops. Many researchers have reported increase in growth and yield of produce with the application of organic manures along with inorganic fertilizers in vegetable crops (Singh 2009; Sati et al. 2018; Wang et al. 2017). A new approach to the balanced use of fertilizers, soil test crop response (STCR) based fertilizer recommendation approach, is also being used now-a-days for estimation of fertilizer nutrient for

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profitable response (Goswami 2006). Research on this approach has been carried out for many of the cereal and pulse crops but for okra and other vegetable crops, it still needs to be refined and developed for each and specific locations. Keeping all these approaches in view, the present experiment was conducted under lowland conditions of Uttarakhand to study the effect of neem coated urea and other nitrogen sources on growth, yield and quality of okra.

Materials and Methods

The fieldwork was carried out at Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District- Udham Singh Nagar, Uttarakhand during the summer seasons of year 2016 and 2017. The soil of the experimental plot was Mollisol having sandy loam soil with neutral pH (7.35 and 6.90), medium organic carbon content (0.72 and 0.78%), low nitrogen (151.8 and 165.12 kg ha^{-1}), high phosphorus (28.5 and 29.91 kg ha^{-1}) and medium potash (168.35 and 181.72 kg ha^{-1}) availability, respectively during both the years. The experiment laid out in Randomized Block Design with three replications consisting following treatment combinations with recommended dose of nitrogen (RDN) through organic (Farm yard manure (FYM) and Vermicompost (VC)] and inorganic [Urea and Neem coated urea (NCU)] sources *viz.,* T_1 (Control), T_2 (RDN- 50% VC + 50% FYM), T_3 (RDN- 100% Urea), T_4 (RDN- 100% NCU), T_5 (RDN- 75% Urea + 25% VC), T_6 (RDN- 75% NCU + 25% VC), T_7 (RDN- 75% Urea + 10 t ha^{-1} FYM), T_8 (RDN- 75% NCU + 10 t ha^{-1} FYM), T_9 (RDN- 100% Urea + 2.5 t ha^{-1} VC), T_{10} (RDN- 100% NCU + 2.5 t ha^{-1} VC), T_{11} (RDN- 100% Urea + 5 t ha^{-1} FYM), T_{12} (RDN- 100% through NCU + 5 t ha^{-1} FYM), T_{13} (STCR with organic) and T_{14} (STCR without organic). Organic manures used in the experiment *viz.,* FYM (0.57% N, 0.32% P_2O_5 and 0.52% K_2O) and VC (1.61% N, 1.17% P_2O_5 and 1.84% K_2O) were applied one week before sowing of seeds. The recommended dose of fertilizers was 100: 40: 40 kg NPK ha^{-1} of which full dose of P_2O_5 and K_2O applied in all treatments (except T_2 and STCR treatments) as basal while, nitrogen doses were applied as per treatments in two equal splits *i.e.,* half as basal and half as top-dress at 30 DAS. Treatment T_2 applied fully as organic while, the soil test-based crop response (STCR) treatments: T_{13} applied with 20 t ha^{-1} FYM, and treatment T_{13} and T_{14} both were applied with inorganic nitrogen source (NCU) in two equal splits, phosphorus (SSP) and potassium (MOP) after working out the doses required as per calculations made using the equations suggested for Mollisol soils by Rawat et al. (2015).

The seeds of okra *cv.* Parbhani Kranti were soaked in water for overnight and were sown after proper seed treatment as line sowing in each plot (net size 3.0 m x 2.25 m) maintaining 50 plants per plot later after thinning at spacing of 45 x 30 cm row-to-row and plant-to-plant. Observations for growth parameters *viz.,* plant height, stem diameter, per plant number of leaves, primary branches and nodes were recorded at 45 days after sowing (DAS) while, leaf area was recorded at 60 DAS. The green pod length, diameter, average weight, number and yield per plant were recorded as yield attributes and yield parameters. The data was subjected for analysis of variance (ANOVA) as per the method suggested by Sukhatme and Panse (1995).

Results and Discussion

Growth parameters: The data pertaining to various growth parameters (Table 1 and Table 2) was found to be significantly affected by various integrated nitrogen treatments. Pooled mean over the years indicated that

Table 1: Effect of neem coated urea on plant height, stem diameter, number of leaves and leaf area

Treatments	Plant height (cm)			Stem diameter (cm)			Number of leaves plant^{-1}			Leaf area (cm^2)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	23.8	20.8	22.3	0.83	0.91	0.87	6.3	6.9	6.6	136.6	142.6	139.6
T_2	31.9	21.3	26.6	0.98	1.02	1.00	6.9	7.5	7.2	185.7	163.7	174.7
T_3	38.2	30.8	34.5	1.04	1.15	1.10	7.1	7.5	7.3	191.2	178.7	185.0
T_4	40.8	32.6	36.7	1.08	1.23	1.15	7.3	7.8	7.6	262.9	237.6	250.3
T_5	39.3	28.7	34.0	1.09	1.18	1.14	7.1	8.1	7.6	292.8	241.7	267.2
T_6	46.2	34.0	40.1	1.17	1.27	1.22	7.6	7.9	7.8	326.6	317.3	322.0
T_7	38.8	32.7	35.8	1.05	1.19	1.12	6.6	7.8	7.2	309.5	264.6	287.1
T_8	39.9	30.0	34.9	1.07	1.23	1.15	7.3	7.9	7.6	198.9	195.4	197.1
T_9	36.7	28.2	32.4	1.12	1.21	1.16	6.9	7.8	7.4	243.4	215.9	229.7
T_{10}	41.1	31.0	36.0	1.13	1.25	1.19	7.0	7.9	7.5	312.3	262.6	287.5
T_{11}	37.5	28.4	32.9	1.00	1.14	1.07	6.1	7.9	7.0	295.4	238.5	267.0
T_{12}	39.5	30.8	35.1	1.06	1.17	1.11	6.8	7.7	7.3	314.2	305.2	309.7
T_{13}	38.4	30.3	34.3	1.03	1.19	1.11	7.2	7.9	7.5	236.7	212.2	224.5
T_{14}	37.4	28.2	32.8	0.97	1.17	1.07	7.0	6.9	7.0	219.2	203.3	211.3
SEm±	1.9	1.5	1.4	0.04	0.04	0.03	0.2	0.2	0.2	15.9	16.5	10.7
C.D. (0.05)	5.7	4.5	4.1	0.13	0.14	0.09	0.8	0.7	0.5	46.5	47.9	31.3

treatment T_6 (RDN- 75% through NCU + 25% through Vermicompost) recorded the maximum plant height (40.1 cm), stem diameter (1.22 cm), number of leaves per plant (7.8) and leaf area (322.0 cm^2), while treatment T_{10} (RDN- 100% through NCU + 2.5 t ha^{-1} Vermicompost) recorded maximum number of primary branches (2.4) and nodes per plant (17.7). Whereas, treatment T_1 (No application of nitrogen) recorded lowest values for all growth parameters. Results from the data indicated that recommended dose of nitrogen in the form of neem coated urea along with vermicompost [Treatment T_6 (RDN- 75% NCU + 25% VC) and T_{10} (RDN- 100% NCU + 2.5 t ha^{-1} VC)] increased growth characters like plant height, stem diameter, number of leaves per plant, leaf area, number of primary branches per plant and number of nodes per plant in comparison to control and sole application of either organic manure or inorganic fertilizer.

Table 2: Effect of neem coated urea on number of primary branches and nodes

Treatments	Number of primary branches $plant^{-1}$			Number of nodes $plant^{-1}$		
	2016	2017	Pooled	2016	2017	Pooled
T_1	1.3	1.8	1.6	8.2	7.3	7.7
T_2	1.5	2.0	1.7	9.7	8.4	9.0
T_3	1.6	2.9	2.3	11.7	11.2	11.5
T_4	1.7	2.1	1.9	14.9	14.2	14.5
T_5	1.7	1.9	1.8	12.5	13.3	12.9
T_6	2.0	2.0	2.0	17.9	17.0	17.5
T_7	1.8	2.9	2.3	14.4	14.1	14.2
T_8	1.8	1.9	1.9	16.2	15.1	15.7
T_9	1.7	2.0	1.9	15.5	15.0	15.2
T_{10}	1.9	2.9	2.4	18.3	17.0	17.7
T_{11}	1.7	2.0	1.9	13.0	12.0	12.5
T_{12}	1.8	2.0	1.9	14.8	13.7	14.2
T_{13}	1.7	2.5	2.1	13.6	12.5	13.1
T_{14}	1.6	2.3	1.9	12.3	11.6	11.9
SEm±	0.07	0.07	0.04	0.2	0.2	0.2
C.D. (0.05)	0.20	0.21	0.14	0.8	0.8	0.7

This could be due to higher photosynthesis rates and vigorous plant growth and development exhibited when supplied with enough nitrogen. Arancon et al. (2003) reported increased plant growth due to large increase in soil microbial biomass after vermicompost applications leading to the production of hormones or humic acids in the vermicompost which act as plant growth regulators independent of nutrient supply. Nutrients in organic manure are released gradually through the process of mineralization maintaining optimal soil nutrient levels over prolonged period (Bationo et al. 2004). The combined application of inorganic and organic sources has beneficial effects on plant growth (Das et al. 2014; Wang et al. 2017). Kumar et al. (2010) also reported significantly higher growth in case of aromatic rice with the application of neem oil coated urea as compared to uncoated prilled urea. Application of vermicompost in combination with inorganic fertilizers has been reported to have higher leaf area (Singh et al. 2010). Garhwal et al. (2010) reported increase in number of primary branches $plant^{-1}$ with combined application of organic and inorganic fertilizers. Similarly, increase in number of nodes $plant^{-1}$ has been reported (Mal et al. 2013; Singh 2009).

Yield and yield attributing parameters: It is evident from pooled data (Table 3) that the green pod length and average green pod weight were not affected by various nitrogen treatments. However, maximum green pod length (11.7 cm) and average green pod weight (13.1 g) were recorded under treatment T_{13} (STCR with organic) and T_9 (RDN- 100% through Urea + 2.5 t ha^{-1} Vermicompost), respectively. While, minimum values for these parameters were recorded under treatment T_9 (RDN- 100% through Urea + 2.5 t ha^{-1} Vermicompost) and T_6 (RDN- 75% through NCU + 25% through Vermicompost), respectively. On the other hand, green

Table 3: Effect of neem coated urea on length, diameter and average weight of green pods

Treatments	Green pod length (cm)			Green pod diameter (cm)			Average green pod weight (g)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	10.7	10.5	10.6	1.38	1.27	1.32	11.8	11.3	11.6
T_2	10.9	11.0	11.0	1.43	1.27	1.35	12.7	12.6	12.7
T_3	10.2	10.3	10.3	1.46	1.43	1.45	12.2	11.3	11.8
T_4	11.5	11.5	11.5	1.37	1.37	1.37	12.9	10.5	11.7
T_5	11.3	11.5	11.4	1.34	1.40	1.37	12.6	11.3	12.0
T_6	11.5	11.3	11.4	1.28	1.47	1.37	12.1	10.9	11.5
T_7	11.3	11.2	11.2	1.46	1.17	1.31	12.4	11.9	12.1
T_8	11.6	11.3	11.5	1.40	1.33	1.36	12.7	11.5	12.1
T_9	8.8	9.2	9.0	1.20	1.07	1.14	12.2	14.0	13.1
T_{10}	10.9	10.8	10.9	1.49	1.47	1.48	12.5	13.3	12.9
T_{11}	11.5	11.3	11.4	1.36	1.37	1.36	12.1	13.9	13.0
T_{12}	10.9	11.0	11.0	1.27	1.27	1.27	12.4	11.9	12.2
T_{13}	11.8	11.7	11.7	1.52	1.50	1.51	12.5	12.4	12.5
T_{14}	9.8	9.8	9.8	1.23	1.27	1.25	12.2	12.2	12.2
SEm±	0.8	1.1	0.7	0.06	0.07	0.06	1.0	1.1	0.8
C.D. (0.05)	NS	NS	NS	NS	0.22	0.18	NS	NS	NS

pod diameter and number of green pods plant^{-1} (Table 3 and Table 4) were found significantly affected. Treatment T_{13} (STCR with organic) and T_6 (RDN- 75% through NCU + 25% through Vermicompost) recorded maximum while, treatment T_9 (RDN- 100% through Urea + 2.5 t ha^{-1} Vermicompost) and T_1 (No application of nitrogen) recorded minimum values for green pod diameter and number of green pods plant^{-1}, respectively.

According to pooled data (Table 4), highest value for green pod yield plant^{-1} was recorded under treatment T_{10} (RDN- 100% through NCU + 2.5 t ha^{-1} Vermicompost) while, treatments T_6 (RDN- 75% through NCU + 25% through Vermicompost) and T_8 (RDN- 75% through NCU + 10 t ha^{-1} FYM) were found *at par.* Whereas, minimum green pod yield plant^{-1} was recorded under treatment T_1 (No application of nitrogen) which was found statistically lowest as compared to other treatments. The effect on green pod length with application of various nitrogen treatment combinations was found non-significant however, a critical analysis of data indicated that higher doses of inorganic fertilizer resulted in some decrease in green pod length. This might be due to toxicity in plants due to excess of nitrogen. Mohammadi et al. (2016) also reported no significant effect of nitrogen on pod length. On the other hand, green pod diameter increased with combined application of recommended dose of nitrogen through neem coated urea and organic manure. Soil test based recommended dose of fertilizer with organic manure recorded maximum green pod diameter. This might be due to increased nitrogen content in pods which resulted in increased pod diameter. An increase in pod diameter has been observed with increased nitrogen application levels along with organic manures (Singh 2009).

However, no influence of various nitrogen treatments was found on average green pod weight of okra but on critical analysis of data, it was observed that treatment with recommended dose of nitrogen through combined inorganic and organic sources application recorded higher average pod weight which might be due to size variations of different pods during sampling. Our results are like the findings of Singh et al. (2010) who reported significantly higher average pod weight with application of vermicompost and inorganic fertilizers. The data (Table 4) indicated that there was a significant increase in number and yield of green pods with combined application of recommended dose of nitrogen through neem coated urea and organic manure [Treatment T_6 (RDN- 75% NCU + 25% VC) and T_{10} (RDN- 100% NCU + 2.5 t ha^{-1} VC)]. The reason behind it might be the slow nutrient releasing property of neem coated urea and organic manure which might have made nutrients available to plants for a longer period whereas, increased microbial activities with application of organic manure which together resulted in continuous increase in plant growth characters thus, increase in number and yield of green pods plant^{-1}. These results are in conformity with the findings of Shalini et al. (2002). Vijaya and Seethalakshmi (2011) in okra also reported higher number and yield of fruits attributed to some positive effects of vermicompost on performance of crop. Similar results for number of pods and pod yield plant^{-1} in okra were reported by Afe and Oluleye (2017) and Das et al (2014).

Table 4: Effect of neem coated urea on number of green pods and green pod yield

Treatments	Number of green pods plant^{-1}			Green pod yield plant^{-1} (g)		
	2016	2017	Pooled	2016	2017	Pooled
T_1	13.6	14.8	14.2	158.7	165.0	161.8
T_2	16.9	16.4	16.6	208.8	202.1	205.4
T_3	17.5	19.4	18.4	212.8	216.3	214.6
T_4	21.6	21.5	21.5	273.2	223.6	248.4
T_5	18.8	22.3	20.5	232.8	249.3	241.0
T_6	25.0	26.7	25.8	296.6	290.0	293.3
T_7	17.7	19.9	18.8	220.2	233.5	226.8
T_8	20.1	23.9	22.0	254.4	275.9	265.2
T_9	17.7	16.0	16.9	216.5	218.9	217.7
T_{10}	22.8	23.7	23.3	280.4	309.1	294.7
T_{11}	19.3	17.5	18.4	226.0	237.0	231.5
T_{12}	18.6	20.3	19.4	229.9	238.4	234.1
T_{13}	18.0	20.1	19.1	223.2	249.7	236.5
T_{14}	18.7	19.5	19.1	223.3	236.1	229.7
SEm±	2.0	1.9	1.4	16.6	18.4	10.7
C.D. (0.05)	NS	5.7	4.0	48.4	53.4	31.1

Conclusion

On basis of present investigation, it can be concluded that application of recommended doses of nitrogen through neem coated urea and vermicompost improves growth parameters *viz.,* plant height, stem diameter, number of leaves plant^{-1}, leaf area, number of primary branches and nodes plant^{-1} and yield parameters *viz.,* number of green pods and green pod yield plant^{-1} in comparison to control. Since, treatment T_{10} (RDN- 100% NCU + 2.5 t ha^{-1} VC) and T_6 (RDN- 75% NCU + 25% VC) both proved to be best for obtaining higher green pod yield plant^{-1} therefore, these could be recommended for commercial production of okra in summer season under lowland conditions to increase productivity of okra provided that all other recommended agronomic package of practices properly followed.

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भिण्डी की वृद्धि और उपज पर नत्रजन के प्रभाव की जांच करने के लिए नत्रजन के जैविक स्रोतों, वर्मीकम्पोस्ट और गोबर की खाद तथा अजैविक स्रोतों, यूरिया और नीम लेपित यूरिया के साथ विभिन्न संयोजनों वाले 14 उपचारों को 3 बार प्रतिकृति कर गोविन्द बल्लभ पंत कृषि एवं प्रौद्योगिकी विश्वविद्यालय, पंतनगर (उत्तराखण्ड) के सब्जी अनुसंधान केन्द्र में वर्ष 2016–17 के ग्रीष्मकाल में की गयी।

बीज बुवाई के 45 दिनों बाद पौधे की ऊँचाई, तने की परिधि, पत्तियों की संख्या, प्राथमिक शाखाओं की संख्या और पार्श्व गांठों की संख्या; 60 दिनों के उपरान्त पत्ती का क्षेत्रफल, हरी फली की लम्बाई व व्यास, हरी फली का औसत वजन, हरी फली की संख्या और प्रति पौध हरी फली की उपज संबंधित आंकड़े लिये गये। निष्कर्षों से स्पष्ट हुआ कि भिण्डी की फसल का प्रदर्शन विभिन्न उपचारों से ज्यादा प्रभावित होता है। सभी उपचारों में उपचार टी$_{10}$ (नत्रजन की अनुशंसित खुराक 100 प्रतिशत नीम लेपित यूरिया एवं 2.5 टन वर्मीकम्पोस्ट के माध्यम से) और टी$_{6}$ (75 प्रतिशत नीम लेपित यूरिया + 25 प्रतिशत वर्मीकम्पोस्ट के माध्यम से) पौधों की वृद्धि व उपज गुणों में सुधार के साथ अति उत्तम पाया गया। अतः भारत वर्ष के तराई क्षेत्रों में ग्रीष्मकाल में भिण्डी की अधिक उपज प्राप्त करने के लिए इनकी अनुशंसा की जा सकती है।

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