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Response of integrated nitrogen management on growth, yield and economics of winter baby corn (*Zea mays* L.)

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Abstract

Baby corn is a de-husked, immature maize ear picked before fertilization after 1-2 days of silking at a 2-3 cm long silk stage. Nitrogen (N) is the primary nutrient required for rapid plant growth and development. Combined uses of organic and inorganic sources possess more agronomic and environmental benefits than inorganic ones. Organic manures, *viz.* farmyard manure (FYM) and vermicompost (VC) are important sources of plant nutrients sustaining soil physic0-chemical and biological properties and crop yield. Investigations are needed to determine the location-specific information on integrated management of recommended doses of nitrogen (RDN) for the winter season crop. An experiment executed in a randomized block design with seven treatments to assess response to various options of integrated nitrogen management for efficient utilization by winter baby corn. Maximum plant height (cm), number of green leaves plant^{-1}, leaf area index, dry matter accumulation plant^{-1} (g) noted with the application of 100 % RDN + 25% RDN as VC. Similarly, yield attributes *viz.* baby cob, baby corn and green fodder yield were also significantly highest with 100 % RDN + 25 % RDN as VC over other treatments. Results suggest winter baby corn (CMVL Baby Corn 2) be grown with the application of 100 % RDN (150 kg ha^{-1}) as an inorganic source + 25 % RDN (37.5 kg ha^{-1}) as VC to achieve higher yield and net returns.

Key words: Baby corn, integrated nitrogen management, farmyard manure, vermicompost, organic manure, inorganic fertilizer

Introduction

Baby corn (*Zea mays* L.) is a de-husked, immature corn ear picked before fertilization 1-2 days after silking with 2-3 cm long silk. The ears are light yellowish to creamy and are generally preferred as 10 to 12 cm in length and 1 to 1.5 cm in diameter. Baby corn is suitable for diversification, food processing industries and value-addition. Besides, it provides a significant quantity of nutritious green fodder with high digestibility after the baby cob harvest and a higher net profit (Singh *et al.,* 2009; Singh *et al.,* 2010). Short duration, fast growth, high yield and wider adaptability make baby corn a superior choice for intensive cropping systems as a potential alternative for diversification and value addition (Dass *et al.,* 2008).

Nitrogen serves as the fundamental component of proteins, amino acids, chlorophyll molecules, and nucleic acids. Acknowledged as a crucial factor influencing plant growth and development, it plays a significant role in determining the yield of crops (Prakash, 2019). In the context of baby corn production, a deficiency in nitrogen can impede economic yield, making it a pivotal consideration. Conversely, an excess of nitrogen is frequently observed in cereals. Effective nitrogen management is essential to mitigate losses and enhance nitrogen use efficiency.The key step in the successful management of N includes diagnosis of deficiency, the accurate quantity of fertilizers, improvement in use efficiencies and use of organic manures (Singh *et al.,* 2019). Baby corn is a relatively new crop thus, limited research work is available under Indian conditions. Baby corn, a heavy feeder crop, requires high population density and more nitrogen application. In the recent past, the continuous adoption of exhaustive cropping systems and irrational use of synthetic fertilizers has resulted in the deterioration of soil health, organic carbon content, soil microbial population and severe micronutrient deficiencies with environmental pollution. Sustaining yields, improvement in nutrient use efficiency and restoration of soil health and quality largely depend on the integrated use of inorganic fertilizers with organic manures and have become an established technique in recent years. Combined use of organic and inorganic sources is better than inorganic alone because this judicious combination has several agronomic and environmental benefits. Vermicompost is a good source of macro and micro plant nutrients and contains plant growth-regulating substances such as humic acids (Carlos *et al.,* 2008), auxins, gibberellins, and cytokinins (Singh *et al.,* 2008) with low C/N ratio and considerably high N (Hřebečková *et at*., 2019). Inorganic nitrogen promotes early growth while at a later stage plant growth is supported by organic sources. The sole use of inorganic fertilizers diminishes soil biochemical activities while conjunctive use with vermicompost improves baby cob and green fodder yield with an increase in soil organic carbon, soil fertility, cation exchange capacity, and microbial and enzyme activity. Organic sources produce organic acid upon their decomposition and improve availability due to solubilization of nutrients in the rhizosphere. Application of the recommended dose of fertilizers (RDF: 150-60-60 kg N- P_2O_5- K_2O ha^{-1}) with vermicompost improved baby corn productivity and soil health (Sharma and Banik, 2014). Partially substitution (25%) of the recommended dose of nitrogen (RDN) as FYM enhanced yields, NPK content and uptake, and quality (sugar, starch, carbohydrate, and protein content) of baby corn (Singh *et al.,* 2010). Organic manures, *viz.,* farmyard manure, is an important source sustaining soil physico-chemical and biological properties and yield (Sivagamy *et al.,* 2021). The application of 150-75-40 kg NPK ha^{-1} along with 10 t FYM was optimal for harvesting a high yield of baby corn with quality fodder (Asaduzzaman *et al.,* 2014). Evidence suggests that judicious use of inorganic fertilizers and organic manures benefits productivity, produce quality, economic returns and soil fertility (Kumar *et al.,* 2018). Growing of winter baby corn in India is still uncommon thus information is scarce. Winter season crop with longer duration and harvest period, and favorable environmental conditions provides ample opportunities to assess integrated nitrogen management for efficient utilization by crop (Neupane *et al.,* 2017a).

The paper investigates nitrogen (N) requirements for winter baby corn, emphasizing the importance of this primary nutrient. It evaluates the agronomic benefits of combining organic (FYM, VC) and inorganic nitrogen sources, focusing on their impact on soil properties and crop yield.

Materials and methods

A study was conducted during the winter season of 2020-21 at Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh to evaluate the response of integrated nitrogen management on growth, productivity and economic returns of winter baby corn. The experimental site lies at 25°18' North latitude and 83°03" East longitude and an altitude of 75.7 meters above mean sea level in the Northern Gangetic alluvial plains. The soil was sandy clay loam in texture, neutral in reaction (soil pH 7.1), low in available nitrogen (185.6 kg ha^{1}), organic carbon (0.42) and medium in available phosphorous (18.70 kg ha^{1}) and potassium (240.92 kg ha^{1}). The experimental site falls in a subtropical climate with exorbitant hot summers and cold winters. Little rainfall (13.2 mm) was received during the growing of the test crop and the average minimum to maximum temperature ranged between 7.3°C to 38.8°C. A set of treatments that included supplementation of RDN solely as inorganic or combined with organic sources (FYM and VC) in varied proportions (25 % and 50 %) have been attempted. An experiment consisted of seven treatments *viz.* 100 % RDN as an inorganic source, 50 % RDN + 50 % RDN as FYM, 75 % RDN + 25 % RDN as FYM,100 % RDN + 25 % RDN as FYM, 50 % RDN + 50 % RDN as VC, 75 % RDN + 25 % RDN as VC and 100 % RDN + 25 % RDN as VC was laid out in randomized block design replicated thrice. The 150 kg N ha^{-1} was applied as the recommended dose in three splits *i.e.* 50 % basal, 25% at the knee height stage and 25 % at the tasseling stage. Uniform basal application of 75 kg P_2O_5 and 60 kg K_2O ha^{-1} followed for all the treatments. The fertilizer and manure sources used were urea, diammonium phosphate, muriate of potash, farmyard manure, and vermicompost.

Results and discussion

Growth parameters: The data (Table 1) exhibits that the growth attributes *viz.* plant height, green leaves and dry matter accumulation $plant^{-1}$ (g) at harvest and, leaf area index (LAI) and chlorophyll content (SPAD value) at 60 and 90 days after sowing (DAS) of baby corn were significantly influenced by nitrogen management practices. The maximum values of the above growth attribute were recorded with the application of 100 % RDN + 25% RDN as VC (T_7). Extra application of 25% RDN as VC (T_7) than T_1 (100 % RDN) produced significantly taller plants over the rest of the treatments. Fertilizing a greater proportion of RDN to baby corn *i.e.,* 50 % RDN as FYM or VC (T_2 and T_5) produced significantly least green leaves, plant height, and dry matter accumulation $plant^{-1}$, LAI and chlorophyll content (60 and 90 DAS). Improvement in growth attributes was because of enhanced dose and supply of N in addition to RDN *i.e.* 25 % RDN as VC or FYM (T_4 and T_7). Treatment T_4 and T_7 were observed together and found to be comparable to the growth attributes exhibited with the complete application of nitrogen as inorganic fertilizer in Treatment T_1. Enhanced nutrient supplies by organic sources in addition to RDN contributed to vigorous plant growth and ultimately led to better growth parameters, as reported by Rasool *et al.* (2015) and Shakunthala *et al.* (2018). However, the inferior performance due to greater N substitution treatments (T_2 or T_5) may be attributed to the fact that the mineralization of organic manures (FYM and VC) usually takes 25-30 days in soil and then becomes available to plants (Neupane *et al.,* 2017a and Singh *et al.,* 2019).

Yield attributes and yield: Data on the effect of integrated nitrogen management practices on the final plant stand ha^{-1}, 50 % silk emergence, initiation of baby cob harvest, baby cobs $plant^{-1}$, baby cob weight, baby corn weight, baby cob length (cm) and baby corn girth (cm) are presented in Table 2. The final plant stand (ha^{-1}) of baby corn was unaffected and found uniform in all the treatments. In general, 100 % RDN + 25 % RDN as VC (T_7) proved its significant superiority over treatments that include the application of either half (T_2 and T_5) or one-fourth

Table 1. Effect of integrated nitrogen management on growth parameters of winter baby corn

Treatments	Plant height (cm)	Green leaves $plant^{-1}$	Dry matter accumulation $plant^{-1}$ (g)	Leaf area index		Chlorophyll content (SPAD value)	
		At harvest		60 DAS	90 DAS	60 DAS	90 DAS
T1: 100 % RDN	150.55	12.68	59.37	1.25	4.43	26.51	41.34
T2: 50% RDN + 50% RDN as FYM	128.86	10.01	38.68	1.20	3.29	23.80	35.37
T3: 75% RDN + 25% RDN as FYM	145.12	12.01	47.86	1.11	3.95	25.10	38.61
T4:100% RDN + 25% RDN as FYM	156.99	13.56	59.99	1.26	4.45	26.91	41.57
T5: 50% RDN + 50% RDN as VC	135.82	10.79	39.12	1.19	3.23	23.40	36.81
T6: 75% RDN + 25% RDN as VC	155.07	12.79	48.64	1.09	4.12	24.97	38.87
T7: 100% RDN + 25% RDN as VC	162.63	14.67	61.33	1.33	4.47	28.87	44.24
S.Em±	1.70	0.91	2.12	0.05	0.28	0.87	1.65
CD (P=0.05)	5.24	2.81	6.53	0.15	0.87	2.67	5.08

CD: critical difference; S Em±: standard error of mean, RDN= Recommended dose of nitrogen, FYM= Farm yard manure, VC= Vermicompost

Table 2. Effect of integrated nitrogen management on yield attributes of winter baby corn

Treatments	Final plant stand ha^{-1} (No. ×10^3)	Initiation of baby cob harvest (No. of days)	50% silk emergence (No. of days)	Baby cob weight (g)	Baby corn weight (g)	Baby cob (No.'s)	Baby corn length (cm)	Baby corn girth (cm)
T_1- 100 % RDN	119.63	99.33	101.67	41.27	8.55	2.23	8.87	1.56
T_2-50% RDN + 50% RDN as FYM	117.99	96.00	99.00	27.77	5.39	1.38	7.38	1.20
T_3- 75% RDN + 25% RDN as FYM	118.31	98.33	100.00	36.87	7.45	1.97	8.46	1.30
T_4-100% RDN + 25% RDN as FYM	119.37	100.00	102.67	41.80	9.02	2.73	9.08	1.66
T_5-50% RDN + 50% RDN as VC	117.91	96.67	99.67	28.60	5.52	1.60	7.55	1.22
T_6-75% RDN + 25% RDN as VC	118.05	99.00	100.33	37.77	7.59	2.13	8.81	1.32
T_7- 100% RDN + 25% RDN as VC	120.16	101.00	103.00	44.23	9.55	3.00	9.26	1.69
S Em±	1.53	0.96	0.78	1.82	0.43	0.31	0.35	0.12
CD (*P*=0.05)	NS	2.96	2.41	5.62	1.32	0.96	1.07	0.36

Table 3. Effect of integrated nitrogen management on yield and economics of winter baby corn

Treatments	Baby cob yield (t ha^{-1})	Baby corn yield (t ha^{-1})	Baby cob: baby corn ratio	Fodder yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit: cost ratio
T_1- 100 % RDN	8.74	1.78	4.83	30.57	76987.99	312154.00	235166.01	3.05
T_2- 50% RDN + 50% RDN as FYM	5.27	0.97	5.19	24.68	90797.27	181716.00	90918.73	1.00
T_3- 75% RDN + 25% RDN as FYM	7.73	1.47	4.94	26.60	84333.63	260094.50	175760.87	2.08
T_4-100% RDN + 25% RDN as FYM	8.85	1.81	4.64	29.98	84487.99	317070.00	232582.01	2.75
T_5- 50% RDN + 50% RDN as VC	6.79	1.27	5.24	25.73	96679.27	228451.00	131772.23	1.36
T_6-75% RDN + 25% RDN as VC	8.12	1.76	4.97	27.34	86833.63	305154.00	218320.37	2.51
T_7- 100% RDN + 25% RDN as VC	8.94	1.85	4.63	31.96	87281.99	325444.00	238162.01	2.73
S Em±	0.94	0.23	0.16	1.94	-	35319.18	35319.18	0.41
CD (*P*=0.05)	2.05	0.50	NS	4.23	-	76953.88	76953.88	0.91

CD: critical difference; S Em±: standard error of mean, RDN= Recommended dose of nitrogen, FYM= Farm yard manure, VC= Vermicompost

(T_3 and T_6) of RDN as FYM or VC for the majority of the yield attributes *viz.* 50 % silk emergence (delayed), baby cob weight, baby corn weight and baby cob girth. Fertilizing baby corn with T_7 caused a significant delay in starting baby cob harvest, more cobs and superior cob length over T_2 and T_5 when 50 % RDN was added as FYM or VC with 50 % through the inorganic source. However, 25% higher nitrogen application as VC (T_7) or FYM (T_4) in addition to 100 % RDN observed at par. Mahapatra *et al.* (2018) and Dadarwal *et al.* (2009) also obtained similar results.

Due to integrated nitrogen management practices, significant variations registered in yields (cob, corn and fodder). The baby cob and baby corn yield responses were in order of $T_7 > T_4 > T_1 > T_6 > T_3 > T_5 > T_2$ (Table 3). Applying 25 % higher nitrogen as VC (T_7) produced 5.0 % higher baby corn yield than 100 % RDN applied through an inorganic source (T_1). Maximum yield of green fodder noticed with T_7 (100% RDN + 25 % RDN as VC) followed and at par with T_4 and T_1 though statistically greater over other treatments (T_2, T_3, T_5, T_6). Further, the treatments T_1 and T_7 registered a narrow baby cob: baby corn ratio and it was wider with the application 50 % of RDN as FYM or VC (T_2 and T_5). The excellent yield response was exhibited because the application of 100 % RDN + 25% RDN as VC (T_7) may be associated with the maintenance of optimum nitrogen supply matched with the crop demand facilitated conducive conditions (Neupane *et al.,* 2017b).

Economics: The cultivation cost was minimal with the sole use of inorganic fertilizer (T_1). The expenditure on integrated nitrogen management practices was greater with higher substitution of RDN with FYM (T_2) followed by VC (T_5). The highest gross return was noted with the application of 100 % RDN + 25 % RDN as VC (T7), followed by 100 % RDN + 25 % RDN as FYM (T_4). The highest net return received (₹ 238162.01 ha^{-1}) with an application of 100 % RDN + 25 % RDN as VC (T_7) while the B: C ratio was highest (3.05) with the addition of 100 % RDN through inorganic fertilizer (T_1).

Results suggest that the substitution of twenty-five or fifty percent recommended nitrogen dose as FYM or VC was not beneficial regarding yields and net returns of baby corn. Winter baby corn variety (CMVL Baby Corn 2) requires higher nitrogen thus, be grown by integration of RDN (150 kg ha^{-1}) as an inorganic source + 25 % RDN (37.5 kg ha^{-1}) as VC to achieve higher yield and net returns in eastern Uttar Pradesh.

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