E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; SP-8(9): 110-114
Received: 27-06-2025
Accepted: 29-07-2025

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Influence of SSNM and STCR approach on growth and yield attributes of maize (*Zea mays* L.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9Sb.3750

Abstract
The field experiment was conducted during kharif 2024 at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule to study growth and yield attributes of maize (*Zea mays* L.).” on variety Phule Champion as influenced by nutrient management through SSNM and STCR fertilization approaches. The experiment was laid out in randomized block design with three replications. The treatments comprised of eight nutrient management *viz*., T_1- Absolute control, T_2 - GRDF (120: 60: 40 N: P_2O_5: K_2O kg ha^{-1} + FYM 10 t ha^{-1}), T_3- SSNM Yield target 8 t ha^{-1}, T_4- SSNM Yield target 10 t ha^{-1}, T_5 - SSNM Yield target 12 t ha^{-1}, T_6 - STCR Yield target 8 t ha^{-1}, T_7 - STCR Yield target 10 t ha^{-1} and T_8 - STCR Yield target 12 t ha^{-1}. Among the treatments, SSNM through fertilizers for targeted yield of 12 t ha^{-1} (T_5) recorded higher plant height, number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$ (dm^2), dry matter $plant^{-1}$, cob length with husk, cob girth with husk, weight of cob with husk, number of grain rows cob^{-1}, number of grains row^{-1} and grain weight cob^{-1} as compared to other treatments.

Keywords: SSNM, STCR, yield target, maize, growth, yield attributes

Introduction
Maize (*Zea mays* L.) is one of the major food grain cereal crop of tropics and subtropics. Origin of maize is southern Mexico. Maize is commonly known in India as Makka. Being poaceae family crop, maize is often called the "queen of cereals". Protein content is around 8-12% and approximately 61% to 78% starch on a dry basis. Since maize is an exhaustive crop, the nutrient requirement cannot be met only through native nutrient reserves; hence, additional nutrients can be met by fertilizer application. Maize gives significant response to fertilizers. In this sense the SSNM and STCR approach is popularised nowadays. Site specific nutrient management (SSNM) is a soil or crop-based feeding approach which important in point of view of farmers for saving fertilizer amount and cost. It is important because of nowadays focus is on sustainable agriculture. SSNM involves use of specific fertilizer inputs and sustainable resource use. SSNM is best to farming system that utilize, and notably abuse, N fertilizers. SSNM decreases the amount of nitrogen abuse, N fertilizers. Adoption of SSNM procedures led in a 30 percent reduction in the usage of fertilizers in rice in one study (Wang *et al.*, 2007) [8]. STCR involves soil analysis and fertilizer recommendation based on STCR equation. SSNM involves three steps *viz*., first assess the indigenous nutrient suppling capacity of soil, second step set yield target and third step supply nutrient to fill the deficit between crop need and indigenous supply. It involves the plant and soil-based approach which carried out for assess the plant and soil nutrient demand. SSNM involves four principles (4R’s) i.e., Right time, Right place, Right rate and Right product.

Materials and Methods
The field experiment was conducted during kharif 2024 at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule. The soil of experimental field was deep, black in colour with good drainage. The experiment was laid out in randomized block design with eight treatments and replicated thrice. The treatments comprised of eight nutrient management *viz*., T_1- Absolute control, T_2 - GRDF (120: 60: 40 N: P_2O_5: K_2O kg ha^{-1} + FYM 10

t ha^{-1}), T_3- SSNM Yield target 8 t ha^{-1}, T_4- SSNM Yield target 10 t ha^{-1}, T_5 - SSNM Yield target 12 t ha^{-1}, T_6 - STCR Yield target 8 t ha^{-1}, T_7 - STCR Yield target 10 t ha^{-1} and T_8 - STCR Yield target 12 t ha^{-1}. Maize was sown on 26th June 2024 and Harvested on 28th September 2024. Treatments were set based on soil nutrient status to achieve targeted yield in maize through SSNM, STCR and these treatments were compared with GRDF (120: 60: 40 N: P_2O_5: K_2O kg ha^{-1} +FYM 10 t ha^{-1}) and Absolute control.

Note: FYM @ 10 t ha^{-1} was applied for all treatments (Except T_1)

The nutrients required to achieve target yield through site specific nutrient management (SSNM) treatments (T_3, T_4 and T_5) was calculated by using the formulae as given by (Biradar and Jayadeva, 2013) [1]

FA = Nutrient uptake by crop per tonne grain yield × T × $\underline{+}$% EFR

Where,
FA - Fertilizer amount required to achieve target yield in kg ha^{-1},
Nutrient uptake - Nutrient uptake by the crop per tonne of grain yield in the respective crop and location,
T - Target yield (t ha^{-1}),
EFR - Effective Fertilizer Rate.
% EFR = 30% more or less fertilizer to be applied as per the soil nutrient (N, P_2O_5 and K_2O) supply capacity, if soil nutrient supply capacity is low apply 30% more quantity of nutrients, soil nutrient supply capacity is medium then apply exactly removed quantity of nutrients and soil nutrient supply capacity is more then apply 30% less quantity of nutrients.

The quantity of fertilizer for targeted yield treatments (T_6, T_7 and T_8) was calculated by using STCR targeted yield equation developed by Soil Test Crop Response (STCR) Project, Mahatma Phule Krishi Vidyapeeth, Rahuri for *kharif* maize.

Fertilizer prescription equation with FYM for Maize (grain)

FN (kg ha^{-1}) = (3.88 X Target yield qt ha^{-1}) - (0.56 X SN) - (3.19 X FYM)

FP_2O_5 (kg ha^{-1}) = (1.91 X Target yield qt ha^{-1}) - (0.99 X S P_2O_5) - (1.46 X FYM)

FK_2O (kg ha^{-1}) = (2.09 X Target yield qt ha^{-1}) - (0.13 X S K_2O) - (1.08 X FYM)

Where,
FN, FP_2O_5, FK_2O = Fertilizer N, P_2O_5 and K_2O (kg ha^{-1}), respectively.
T = Yield target (qt ha^{-1})
SN, SP_2O_5 and SK_2O = Soil available N, P and K (kg ha^{-1})
FYM = Farm Yard manure in t ha^{-1}

Results and Discussion

Effect of targeted yield approaches on growth attributes of maize

Plant height

Plant height (at harvest) of maize was significantly higher with application of nutrients based on SSNM for a target yield of 12 t ha^{-1} (218.73 cm) and STCR 12 t ha^{-1} (217.53 cm) where it was the lowest in Absolute control (156.93 cm) (Table 1). Application of nitrogen in vegetative growth stage which leads to vigorous plant growth. The application of different levels of fertilizer leads to variability of plant height in different growth stages of maize. These results are correlate with Biradar *et al.*, (2013) [2] and Shreenivas *et al.*, (2017) [6].

Number of functional leaves

The number of functional leaves plant^{-1} (at harvest) of maize was significantly higher with application of nutrients based on SSNM for a target yield of 12 t ha^{-1} (5.61) and STCR target yield 12 t ha^{-1} (5.58). Significantly lower number of functional leaves plant^{-1} was recorded in treatment Absolute control (3.10) (Table 1). Higher number of functional leaves plant^{-1} may be due to higher assimilation rate, cell division and metabolic activities in plant. Site specific nutrient management increase the availability of nutrient in soil for plant growth which results in more absorption and higher uptake of nutrients by crop leads to better plant growth. Similar results are reported by Biradar *et al.*, (2013) [2] and Shreenivas *et al.*, (2017) [6].

Leaf area (dm^2 plant^{-1})

The leaf area plant^{-1} (at harvest) of maize was significantly higher with application of nutrients based on SSNM for a target yield of 12 t ha^{-1} (27.10 dm^2 plant^{-1}) and STCR target yield 12 t ha^{-1} (26.24 dm^2 plant^{-1}). Significantly lower leaf area was recorded in treatment Absolute control (19.50 dm^2 plant^{-1}) (Table 1). Increase in leaf area plant^{-1} mainly due to increase amount of cellular protoplasm and proteins. This results in expansion of cell wall which was manifested in increase in length and breadth of leaves of the plant. Similar result reported by Vikram *et al.*, (2015) [7] and Biradar *et al.*, (2013) [2].

Dry matter plant^{-1} (g)

The dry matter plant^{-1} (g) (at harvest) of maize was significantly higher with application of nutrients based on SSNM for a target yield of 12 t ha^{-1} (379.42 g) and STCR target yield 12 t ha^{-1} (376.73 g). Significantly lower dry matter plant^{-1} (g) was recorded in treatment Absolute control (189.09 g) (Table 1). The higher dry matter plant^{-1} might be due to more leaf area exposed to sunlight with which rapid photosynthetic rate helped in accumulation of higher dry matter in plant. This result is coincided with Shreenivas *et al.*, (2017) [6] and Vikram *et al.*, (2015) [7].

Yield parameters

Length of cob with husk (cm)

The significant difference in cob length was observed due to soil test based nutrient management approach. The longer cobs with husk were observed in T_5: SSNM for target yield 12 t ha^{-1} (22.93 cm) followed by T_8: STCR for target yield 12 t ha^{-1} (22.20 cm). The significantly shorter cobs were observed in T_1: Absolute control (19.59 cm) followed T_2: GRDF (19.72 cm) (Table 2). It might be due to better growth attributes *viz*., Plant height, number of green leaves, leaf area, dry matter production and distribution etc. The higher leaf area per plant was responsible to capture of more solar radiation resulting in high photosynthetic rate which in turn resulted in higher dry matter production. All these factors associated with leaf area contributed towards significant improvement in growth and yield attributes and ultimately resulted in higher cob length. These results are similar with the findings of Biradar and Jayadeva (2013) [1] and Shreenivas *et al.*, (2017) [6].

Girth of cob with husk (cm)

The larger cob girth with husk were observed in T_5: SSNM for target yield 12 t ha^{-1} (19.44 cm) followed by T_8: STCR for target yield 12 t ha^{-1} (19.20 cm). The significantly smaller cob girth were observed in T_1: Absolute control (14.34 cm) followed by T_2: GRDF (16.67 cm) (Table 2). The larger cob girth might be due to site specific, sufficient and balanced supply of plant nutrients which increases the uptake, translocation and assimilation of plant nutrients. These results were similar to those reported by Biradar and Jayadeva (2013) [1] and Shreenivas *et al*., (2017) [6].

Weight of cob with (g)

The highest cob weight with husk were observed in T_5: SSNM for target yield 12 t ha^{-1} (238.36 g) followed by T_8: STCR for target yield 12 t ha^{-1} (234.98 g). The significantly lowest cob weight were observed in T_1: Absolute control (142.15 g) followed T_2: GRDF (196.37 g) (Table 2). Higher yield attributes may be due to right amount and right proportions of plant nutrients supplied to the crop, resulting increment in availability of these nutrients to plants, which favoured the vegetative growth, increased photosynthetic activity leads to increased weight of cob with husk as observed in the present investigation, which is correlated with the findings Biradar and Jayadeva (2013) [1] and Vikram *et al*., (2015) [7].

Number of grain rows cob^{-1}

The maximum number of grain rows cob^{-1} was observed in T_5: SSNM for target yield 12 t ha^{-1} (15.47) which was on par with T_7: STCR for target yield 12 t ha^{-1} (15.33). The significantly minimum number of grain rows cob^{-1} was observed in T_1: Absolute control (12.93) followed by T_2: GRDF (13.47) (Table 2). The number of grain rows cob^{-1} were significantly influenced due to different treatments because number of grain rows cob^{-1} is depended on girth of cob and has direct relationship. In this experiment the increase in dose of fertilizer resulting in increase in girth of cob which leads to increase the number of grain rows cob^{-1}.

Number of grains row^{-1}

The number of grains row^{-1} is important yield attributes which are significantly higher in application of nutrients by T_5: SSNM for target yield 12 t ha^{-1} (31.49) followed by T_7: STCR for target yield 12 t ha^{-1} (31.15). Markedly less number of seeds row^{-1} is obtained in T_1: Absolute control (24.25), followed by T_2: GRDF (28.98) (Table 2). Cob length influences the number of grains $rows^{-1}$ and has direct relationship. Therefore, higher cob length may be leads to a greater number of grains row^{-1}. These results also reported by Biradar and Jayadeva (2013) [1] and Vikram *et al*., (2015) [7].

Grain weight cob^{-1}

Significantly highest grain weight cob^{-1} was recorded in T_5: SSNM for target yield 12 t ha^{-1} (165.91 g) followed T_8: STCR for target yield 12 t ha^{-1} (162.47 g). The significantly lowest grain weight cob^{-1} were observed in T_1: Absolute control (69.02 g) followed by T_2: GRDF (124.78 g) (Table 2). Higher grain weight cob^{-1} in the site-specific nutrient treatment could be ascribed to the increased cob length, higher number of grain rows cob^{-1}, which was essential for higher number of grains cob^{-1}. Similar results are observed by Desai *et al.*, (2017) [3].

Grain yield (qt ha^{-1})

The higher grain yield of maize were recorded with application of fertilizers based on SSNM for a target yield of 12 t ha^{-1} (90.90 qt ha^{-1}) and STCR target yield 12 t ha^{-1} (90.70 qt ha^{-1}). Among other SSNM Yield target 10 t ha^{-1} (T_4) (89.07 qt ha^{-1}) and STCR Yield target 10 t ha^{-1} (T_7) (88.37 qt ha^{-1}) were statistically at par. Significantly lower grain yield was recorded in treatment Absolute control (25.32 qt ha^{-1}) (Table 3). The increased yield due to availability of nitrogen, phosphorus and potassium in higher quantity which increases the uptake of nutrient and accumulation of this nutrient in plant which results increment in number of grains cob $^{-1}$, 100 seed weight, grain weight cob^{-1} which ultimately result in higher grain yield ha^{-1}.This results is correlate with the finding of Biradar *et al.*, (2013) [2], Vikram *et al.*, (2015) [7] and Raghuramakrishnan *et al.*, (2021) [4]

Stover yield (qt ha^{-1})

The higher stover yield of maize were recorded with application of fertilizers based on SSNM for a target yield of 12 t ha^{-1} (101.81 qt ha^{-1}) and STCR target yield 12 t ha^{-1} (101.59 qt ha^{-1}). Among other SSNM Yield target 10 t ha^{-1} (T_4) (101.54 qt ha^{-1}), STCR Yield target 10 t ha^{-1} (T_7) (101.52 qt ha^{-1}), SSNM Yield target 8 t ha^{-1} (T_3) (92.41 qt ha^{-1}) and STCR Yield target 8 t ha^{-1} (T_6) (92.33 qt ha^{-1}) were statistically at par. Significantly lower stover yield was recorded in treatment Absolute control (35.45 qt ha^{-1}) (Table 3). The availability of nutrients in the sufficient amount under SSNM Yield target 12 t ha^{-1} (T_5) treatment resulted in greater accumulation, translocation and assimilation of carbohydrates and amino acids which led to improved stover yield. The stover yield is an outcome of the improved growth particularly in terms of plant height, number of leaves and dry matter accumulation in the plants. Similar results are observed in findings of Biradar *et al.*, (2013) [2], Shinde *et al.*, (2014) [5], Vikram *et al*., (2015) [7].

Biological yield (qt ha^{-1})

The significantly higher biological yield were recorded in SSNM Yield target 12 t ha^{-1} (T_5) treatment was 192.71 qt ha^{-1} than rest of the treatments. However, found statistically at par with STCR Yield target 12 t ha^{-1} (T_8) treatment was 192.29 qt ha^{-1}, SSNM Yield target 10 t ha^{-1} (T_4) (190.61 qt ha^{-1}) and STCR Yield target 10 t ha^{-1} (T_7) (189.89 qt ha^{-1}). Significantly lower biological yield was found in Absolute control (T_1) treatment was 60.77 qt ha^{-1} (Table 3). Biological yield is addition of grain yield and stover yield. More grain and stover yield in SSNM Yield target 12 t ha^{-1} (T_5) in this treatment had higher biological yield.

Table 1: Effect of SSNM and STCR nutrient management on plant height (cm), number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$ and dry matter $plant^{-1}$ (g) at harvest of maize at harvest stage.

Tr. No.	Treatment details	Plant height (cm) at harvest	Number of functional leaves plant^{-1} at harvest	Leaf area (dm^2) plant^{-1} at harvest	Dry matter plant^{-1} (g) at harvest
T_1:	Absolute control	156.93	3.10	19.50	189.09
T_2:	GRDF (120:60:40, kg N, P_2O_5, K_2O ha^{-1} + FYM 10 t ha^{-1})	190.17	3.24	20.90	292.54
T_3:	SSNM Yield target 8 t ha^{-1}	208.12	4.77	23.02	316.88
T_4:	SSNM Yield target 10 t ha^{-1}	213.67	5.12	25.40	374.81
T_5:	SSNM Yield target 12 t ha^{-1}	218.73	5.61	27.10	379.42
T_6:	STCR Yield target 8 t ha^{-1}	206.49	4.47	21.54	313.90
T_7:	STCR Yield target 10 t ha^{-1}	212.40	4.95	24.51	371.17
T_8:	STCR Yield target 12 t ha^{-1}	217.53	5.58	26.24	376.73
SE (m) ±		5.99	0.28	1.19	10.30
C.D. at 5%		18.16	0.84	3.62	31.24

Table 2: Effect of SSNM and STCR nutrient management on cob length with husk, cob girth with husk, weight of cob with husk, number of grain rows cob^{-1}, number of grains row^{-1} and grain weight cob^{-1}.

Tr. No.	Treatment details	Cob length with husk (cm)	Cob girth with husk (cm)	Cob weight with husk (g)	Number of grain rows cob^{-1}	Number of grains row^{-1}	Grain weight cob^{-1}
$T_{1:}$	Absolute control	19.59	14.34	142.15	12.93	24.25	69.02
$T_{2:}$	GRDF (120:60:40, kg N, P_2O_5, K_2O ha^{-1} + FYM 10 t ha^{-1})	19.72	16.67	196.37	13.47	28.98	124.78
$T_{3:}$	SSNM Yield target 8 t ha^{-1}	20.91	17.17	216.22	14.20	30.04	142.55
$T_{4:}$	SSNM Yield target 10 t ha^{-1}	21.95	18.37	232.52	15.07	31.07	159.00
$T_{5:}$	SSNM Yield target 12 t ha^{-1}	22.93	19.44	238.36	15.47	31.49	165.91
$T_{6:}$	STCR Yield target 8 t ha^{-1}	20.41	16.75	214.52	14.13	29.80	140.59
$T_{7:}$	STCR Yield target 10 t ha^{-1}	21.40	18.25	225.98	14.53	30.92	152.37
$T_{8:}$	STCR Yield target 12 t ha^{-1}	22.20	19.20	234.98	15.33	31.15	162.47
SE (m) ±		0.64	0.63	7.22	0.52	0.94	4.06
C.D. at 5%		1.95	1.90	21.91	1.58	2.85	12.30

Table 3: Effect of SSNM and STCR nutrient management on grain yield, stover yield and biological yield.

Tr. No.	Treatment details	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})
$T_{1:}$	Absolute control	25.32	35.45	60.77
$T_{2:}$	GRDF (120:60:40, kg N, P_2O_5, K_2O ha^{-1}+ FYM 10 t ha^{-1})	68.01	85.01	153.02
$T_{3:}$	SSNM Yield target 8 t ha^{-1}	77.66	92.41	170.07
$T_{4:}$	SSNM Yield target 10 t ha^{-1}	89.07	101.54	190.61
$T_{5:}$	SSNM Yield target 12 t ha^{-1}	90.90	101.81	192.71
$T_{6:}$	STCR Yield target 8 t ha^{-1}	76.95	92.33	169.28
$T_{7:}$	STCR Yield target 10 t ha^{-1}	88.37	101.52	189.89
$T_{8:}$	STCR Yield target 12 t ha^{-1}	90.70	101.59	192.29
SE (m) ±		2.83	3.44	6.27
C.D. at 5%		8.59	10.44	19.02

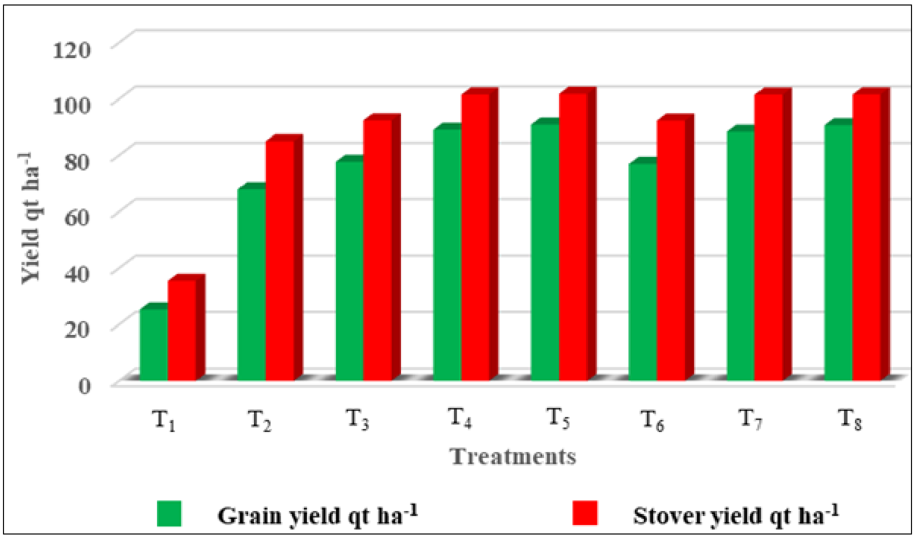

Fig 1: Grain yield and stover yield as influenced by SSNM and STCR based nutrient management approaches in maize.

Conclusion

From this experimentation, it can be concluded that, the treatment $T_{5:}$ SSNM Yield target 12 t ha^{-1} showed higher growth parameters such as plant height (cm), number of functional leaves plant^{-1}, leaf area plant^{-1} and dry matter plant^{-1} (g) at harvest and yield parameters such as cob length with husk, cob girth with husk, weight of cob with husk, number of grain rows cob^{-1}, number of grains row^{-1}, grain weight cob^{-1}, grain yield, stover yield and biological yield respectively by maize

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