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Effect of Soil Test Crop Response Approach on Growth and Yield of Rabi Onion in Inceptisols

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment of fertilizer equation validation was carried out during the Rabi season of 2022-23 to determine the effect of the Soil Test Crop Response (STCR) target equation on the growth and yield of Rabi onion. The experiment was laid out in a randomized block design with ten treatment combinations *viz*., Absolute Control, Generalised Recommended Dose of Fertilizer (GRDF) 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}, As per Soil Test, STCRC target for 250 q ha^{-1} without vermicompost, STCRC target for 300 q ha^{-1} without vermicompost, STCRC target for 350 q ha^{-1} without vermicompost + Biofertilizer, STCRC target for 250 q ha^{-1} with vermicompost, STCRC target for 300 q ha^{-1} with vermicompost, STCRC target for 300 q ha^{-1} with vermicompost + Biofertilizer, Only 5 t ha^{-1} vermicompost. The research findings revealed that treatment T_9 resulted in a significantly higher number of leaves (8.56 and 11.52) at 40 and 80 days after transplanting (DAT), height of crop (42.00 and 57.46 cm) at 40 and 80 days after transplanting (DAT), Chlorophyll (41.30 and 51.84) at 45 and 60 days after transplanting (DAT), polar and equatorial diameter (6.36 and 9.48 cm), neck girth (4.94 cm) and bulb weight (64.09 gm). Similarly, the treatment T_9- STCRC target for 300 q ha^{-1} with vermicompost + Biofertilizer achieved significantly superior bulb yield (363.67 q ha^{-1}) with per cent deviation of 3.90 % and top yield (67.18 q ha^{-1}).

Keywords: STCR; DAT; chlorophyll; vermicompost; biofertilizer.

1. INTRODUCTION

The ‘targeted yield model’ is one of the practical approaches for the efficient use of fertilizers. The theory of formulating optimum fertilizer recommendations for targeted yields was first given by Troug [1] which was further modified by Ramamoorthy [2] as an ‘Inductive-cum targeted yield model’. The addition of an Integrated Plant Nutrition System (IPNS) to this concept ensures balanced fertilization by application of inorganic and organic sources of nutrients.

Onion (*Allium cepa*), belonging to the Alliaceae family portrayed as “Queen of the kitchen” is one of the most important commercial bulb vegetables. India is the second-largest producer next to China with cultivating area, production and productivity of 1.65 million hectares, 27.00 million metric tonnes and 18.3 MT ha^{-1}, respectively [3].

Maharashtra stands as the foremost state in both area coverage and production of onions among the different states. Other significant onion-growing states include Gujarat, Karnataka, Odisha, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, and Rajasthan. Maharashtra ranks 1st in onion production with a share of 28.32 per cent in terms of production. The principal onion-growing districts in the Maharashtra State are Nashik, Satara, Jalgaon, Pune, Solapur and Ahmednagar occupying about 94.68 per cent of the area under cultivation of onion in the State [4,5].

Vermicompost, stands as a rich repository of macro and micronutrients, plant growth regulators, vitamins, and beneficial microflora. This organic resource is hailed for its ability to sustain soil fertility in an environmentally friendly manner, contributing to an eco-friendlier environment [6]. In contrast to inorganic fertilizers, vermicompost is viewed as a superior alternative due to its diverse microbial populations and richness in microbial and enzyme activities, greatly impacting the growth of various plants [7,8].

Biofertilizers, another sustainable and cost-effective option, contain live microorganisms that enhance organic matter content through decomposition, enrich soil fertility in cultivable lands, and aid in the conservation and mobilization of plant nutrients within the soil [9]. These eco-friendly alternatives, recognized for their affordability and effectiveness, are gaining prominence in crop production, serving as a decomposer to organic matter to convert insoluble nutrients into a soluble and accessible form [10]. While organic manures carry nutrients in smaller quantities compared to chemical fertilizers, they also contain growth-promoting elements like enzymes and hormones, contributing not only to improved soil fertility and productivity but also to overall plant growth. In the future, the adoption of organic manures and biofertilizers to fulfil crop nutrient needs will become an essential practice for sustainable agriculture.

The objectives of the study are to validate the derived fertilizer prescription equation through follow-up trials and to check the response of

Table 1. Initial soil Chemical properties of the experimental site

Sr. No.	Particulars	AICRP on STCR	PGI	AICRP on IWM
1	pH (1:2.5)	8.03	7.92	7.87
2	EC (1:2.5) (d S m^{-1})	0.19	0.17	0.20
3	Organic Carbon (%)	0.56	0.50	0.53
4	Available N (kg ha^{-1})	169	158	201
5	Available P (kg ha^{-1})	14	10	14
6	Available K (kg ha^{-1})	437	414	426

vermicompost with biofertilizer on growth parameters.

2. MATERIALS AND METHODS

The present STCR validation experiments were carried out in the Soil Test Crop Response (STCR) field, Post Graduate Institute (PGI) field and AICRP on Irrigation Water Management (IWM) field, MPKV Rahuri during the *rabi* season 2022-23. The experiment was laid out in uniform and nearly levelled land with medium-deep black soil belonging to order Inceptisols. The soil is slightly alkaline, low in nitrogen and phosphorus and high in potassium which is described in Table 1.

The STCR equation on *rabi* onion (Variety- N: 2-4-1) was derived by test crop trial as given below;

i) STCR yield target equation without vermicompost

FN= (0.83 x T) – (0.65 x SN)
FP_0O_5 = (0.41 x T) – (3.21 x SP)
FK_2O = (0.45 x T) – (0.18 x SK)

ii) STCR yield target equation with vermicompost (5 t ha^{-1})

FN= (0.65 x T) – (0.51 x SN – 5.05 VC)
FP_0O_5 = (0.39 x T) – (3.06 x SP – 5.22 VC)
FK_2O = (0.38 x T) – (0.15 x SK – 4.04 VC)

iii) STCR yield target equation with vermicompost (5 t ha^{-1}) and Biofertilizer (*Azospirullum* and *PSB*)

FN= (0.63 x T) – (0.49 x SN – 6.57 VC)
FP_0O_5 = (0.27 x T) – (2.13 SP – 5.00 VC)
FK_2O = (0.36 x T) – (0.15 x SK – 5.49 VC)

Where, F and S indicate fertilizer and soil nutrients, respectively (kg ha^{-1}), t indicates yield target (t ha^{-1}), VC indicates vermicompost (t ha^{-1}), VC + BF indicates vermicompost (t ha^{-1}) + Biofertilizer.

These relationships were further used to compute fertilizer doses for different yield targets of *rabi* onion and varying soil test values.

The experiment was laid out in a randomized block design with three replications. The treatments comprised T_1-Absolute Control, T_2-GRDF, T_3- As per Soil Test, T_4 -STCRC target for 250 qt ha^{-1} without vermicompost, T_5-STCRC target for 300 qt ha^{-1} without vermicompost, T_6-STCRC target for 350 qt ha^{-1} without vermicompost + Biofertilizer, T_7- STCRC target for 250 qt ha^{-1} with vermicompost, T_8- STCRC target for 300 qt ha^{-1} with vermicompost, T_9-STCRC target for 300 qt ha^{-1} with vermicompost + Biofertilizer, T_{10}- Only 5 t ha^{-1} vermicompost.

The observations were recorded such as number of leaves, plant height, chlorophyll, polar diameter, equatorial diameter, neck girth, bulb and straw yield. The data were analysed statistically and results were interpreted using methods suggested by Panse and Sukhatme [11].

3. RESULTS AND DISCUSSION

3.1 Effect of Prescription Based Fertilizer Application on Number of Leaves on Onion Crop

Data on the number of leaves on the onion crop as influenced by different treatments during the *rabi* season, 2022-23 are presented in Table 2. The data on the number of leaves at 40 and 80 DAT on onion crops were influenced significantly by the different nutrient management treatments.

The number of leaves on an onion plant is important for assessing plant health and growth. Too few leaves may indicate nutrient deficiencies, disease, or other stresses that can affect plant development and yield. Conversely, an excessive number of leaves may lead to overcrowding and competition for resources, which can also impact plant growth and bulb development. Those treatments having organic sources such as vermicompost, FYM and biofertilizer applied were observed to have a relatively higher number of leaves.

The pooled data of the number of leaves at 40 DAT ranges 4.33 – 8.56; the treatment absolute control showed a significantly lower number of leaves and treatment T_9- STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer was significantly highest number of leaves. This might be due to the combined treatment bringing synergistic effects of vermicompost and biofertilizer. The increased leaf count increases metabolic activities, likely fuelled by the richer pool of macro and micronutrients derived from vermicompost and biofertilizer. This, in turn, leads to elevated synthesis of carbohydrates and phytohormones, culminating in augmented growth, as elucidated by Gebremichael et al. [12].

Similarly, at 80 DAT, the treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer was observed significantly higher number of leaves (11.52). Plants from the control treatments tended to be stunted and produced fewer leaves than fertilized plots (7.63). A similar increase in the number of leaves on onion with combined application of vermicompost and biofertilizer was observed by Solanki et al. [13] and Vedpathak and Chavan [14].

3.2 Effect of Prescription Based Fertilizer Application on Height (cm) of Onion Crop

Data presenting the height of the onion crop as influenced by different treatments during the *rabi* season, 2022-23 are presented in Table 3. The data with respect to the height of the onion crop at 40 and 80 DAT were influenced significantly by the different nutrient management treatments.

The plant height is an important growth parameter because it indicates photosynthesis, chlorophyll and the overall health of the plant. The increase in plant height plays a direct role in the vegetative and reproductive growth of the crop.

The pooled height of the onion crop at 40 and 80 DAT ranged between 28.77 to 42.00 and 36.23 to 57.46 cm. The treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer has recorded significantly higher crop height (42.00 and 57.46 cm) over all other treatments. The treatment T_6- STCR target 300 q ha^{-1} without Vermicompost + Biofertilizer was at par with treatment T_9. The lowest plant height was noted in the treatment absolute control.

The higher crop height in the treatment with vermicompost application is because the vermicompost was well decomposed and had a higher nutrient content along with other organic acids. Majorly Nitrogen was responsible for increasing onion height hence, those treatments having comparatively higher application of nitrogen fertilizer and organic manure applied showed a significantly higher crop height [15]. A similar increase in the height of the onion crop with the combined application of vermicompost and biofertilizer was observed by Solanki et al. [13] and Monira et al. [16].

3.3 Effect of Prescription Based Fertilizer Application on Chlorophyll Content by SPAD of Onion Crop

Data pertaining to the chlorophyll content of onion crops, as influenced by different treatments, are presented in Table 4. The chlorophyll content of onion crops at 45 and 60 DAT were influenced significantly by the different nutrient management treatments.

Chlorophyll is the pigment responsible for the green colouration in plants and is crucial for photosynthesis, the process by which plants convert light energy into chemical energy to fuel growth and development [17]. The SPAD 502 meter measures the chlorophyll content of live latex tissue of a standing crop. SPAD-502 readings and chlorophyll contents were determined on fully expanded, middle, and recently expanded leaves, which were selected to maximize the visual variation in leaf colour. Each SPAD value obtained was the average of 5 readings [18].

The pooled chlorophyll content of three locations was comparatively higher in treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer (41.30 and 51.84) and lower in treatment T_1 – Absolute Control (30.44 and 35.89). The highest chlorophyll might be due to enhanced photosynthetic activities observed in onion plants under the combined treatment of vermicompost and plant growth-promoting rhizobacteria (PGPR) could be attributed to the

Table 2. Effect of prescription based fertilizer application on number of leaves of onion crop

Tr. No	Treatment details	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
		40 DAT				80 DAT			
T_1	Absolute Control	4.90	4.00	4.10	4.33	8.10	7.20	7.60	7.63
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	6.40	4.70	5.16	5.42	9.24	7.65	8.14	8.34
T_3	As Per the Soil Test	7.20	6.19	6.66	6.68	10.00	8.10	9.37	9.15
T_4	STCR Target 250 q ha^{-1} without Vermicompost	7.00	5.64	6.14	6.26	9.71	7.79	8.46	8.65
T_5	STCR Target 300 q ha^{-1} without Vermicompost	7.50	6.29	6.75	6.85	10.20	8.39	9.60	9.40
T_6	STCR Target 350 q ha^{-1} without Vermicompost + Biofertilizer	8.53	7.26	7.98	7.92	11.57	9.81	10.98	10.79
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	6.60	5.49	5.90	6.00	9.87	7.90	9.00	8.92
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	8.00	7.10	7.55	7.55	10.95	9.20	10.57	10.24
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	9.10	7.73	8.87	8.56	12.38	10.30	11.87	11.52
T_{10}	Only Vermicompost 5 t ha^{-1}	5.98	4.38	4.97	5.11	8.90	7.46	8.00	8.12
	SE m (±)	0.41	0.34	0.40	0.20	0.59	0.53	0.58	0.29
	CD @ 5%	1.21	1.01	1.19	0.56	1.75	1.58	1.71	0.82

Table 3. Effect of prescription based fertilizer application on height (cm) of onion crop

Tr. No	Treatment details	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
		40 DAT				80 DAT			
T_1	Absolute Control	30.18	27.35	28.78	28.77	38.18	33.80	36.70	36.23
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	35.40	32.12	33.80	33.77	44.34	38.60	41.36	41.43
T_3	As Per the Soil Test	37.27	33.85	35.14	35.42	49.37	45.37	48.60	47.78
T_4	STCR Target 250 q ha^{-1} without Vermicompost	36.20	33.10	34.57	34.62	46.10	41.91	44.97	44.33
T_5	STCR Target 300 q ha^{-1} without Vermicompost	37.90	34.50	36.50	36.30	50.80	47.17	50.10	49.36
T_6	STCR Target 350 q ha^{-1} without Vermicompost	42.60	37.61	40.17	40.12	56.70	51.83	54.89	54.47
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	36.00	32.57	34.10	34.22	48.39	42.39	46.37	45.71
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	40.87	35.10	38.90	38.29	53.90	48.28	51.70	51.29
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	43.70	39.57	42.73	42.00	59.40	54.67	58.33	57.46
T_{10}	Only Vermicompost 5 t ha^{-1}	33.60	29.90	31.80	31.77	42.97	37.60	40.60	40.39
	SE m ($\pm$)	1.91	1.61	1.88	0.91	2.58	2.42	2.55	1.27
	CD @ 5%	5.67	4.78	5.59	2.58	7.67	7.20	7.58	3.57

Table 4. Effect of prescription based fertilizer application on chlorophyll content by SPAD

Tr. no	Treatments	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
		45 DAT				60 DAT			
T_1	Absolute Control	32.70	28.34	30.27	30.44	38.60	33.67	35.40	35.89
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	34.90	30.88	33.58	33.12	41.80	38.00	39.59	39.80
T_3	As Per the Soil Test	35.84	33.59	34.28	34.57	45.80	42.00	44.62	44.14
T_4	STCR Target 250 q ha^{-1} without Vermicompost	35.37	32.97	34.00	34.11	42.38	39.40	40.31	40.70
T_5	STCR Target 300 q ha^{-1} without Vermicompost	36.14	34.10	35.71	35.32	46.00	42.20	45.10	44.43
T_6	STCR Target 350 q ha^{-1} without Vermicompost	41.10	37.48	39.84	39.47	51.80	47.82	50.48	50.03
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	35.10	32.67	33.49	33.75	45.21	40.87	42.35	42.81
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	39.50	35.26	37.19	37.32	49.60	44.39	47.67	47.22
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	42.60	39.73	41.56	41.30	53.34	49.36	52.83	51.84
T_{10}	Only Vermicompost 5 t ha^{-1}	34.10	30.24	33.12	32.49	40.72	37.55	39.00	39.09
SE m (±)		1.92	1.76	1.87	0.94	2.41	2.26	2.39	1.19
CD @ 5%		5.71	5.24	5.54	2.65	7.17	6.71	7.09	3.35

advantageous properties of vermicompost over traditional compost. Vermicompost typically contains higher levels of nitrate, a more readily absorbed form of nitrogen for plants. Furthermore, vermicompost releases nutrients over a shorter period compared to compost, as noted by [19] Hassan et al. The treatment T_6- STCR target 350 q ha^{-1} without 5 t ha^{-1} Vermicompost + Biofertilizer (39.47) was at par with treatment T_9. The following result was treatment T_8- STCR target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer, the treatment T_5- STCR target 300 q ha^{-1} without Vermicompost. Similar results were reported by Vishwakarma et al*.* [20], Shedeed et al*.* [21], and Singh and Ram [22].

3.4 Effect of Prescription Based Fertilizer Application on Polar and Equatorial Diameter (cm) of Onion Crop

Data representing the polar diameter of onion crops as influenced by different treatments during the *rabi* season, 2022-23 are presented in Table 5. The polar diameter of an onion bulb refers to the measurement from the top (pole) to the bottom (base) of the bulb, taken along a line perpendicular to the equatorial diameter. This measurement helps to describe the overall size and shape of the onion bulb. Onion bulbs typically have a spherical to slightly elongated shape in nature.

The equatorial diameter of an onion bulb refers to the measurement taken around the widest part of the bulb, perpendicular to the polar diameter. This measurement provides insight into the overall size and shape of the onion bulb and is an essential consideration for growers and consumers. The equatorial diameter plays a significant role in determining the culinary applications and market preferences for onion bulbs.

Before the harvesting stage, the pooled polar and equatorial diameters of the onion crop were found to be remarkably higher in treatment T_9 (STCR target 350 q ha^{-1} with 5 t ha^{-1} vermicompost + biofertilizer) at 6.36 cm and 9.48 cm, respectively, and lower in treatment T_1 (Absolute Control) at 3.86 cm and 6.19 cm, respectively. The treatments T_6- STCR target 300 q ha^{-1} without 5 t ha^{-1} Vermicompost + Biofertilizer and T_8- STCR target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost was at par with treatment T_9. The diameter of the bulb increased significantly with different treatments of organic manures, inorganic fertilizers and biofertilizers. This may be due to the application of organic manures which provide major and micronutrients resulting in increased photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improved the diameter of the bulb [16,23]. The targets that were achieved had the highest diameters compared to all other treatments. Similar significance of results with vermicompost and biofertilizer-like organic sources were observed in Gour et al*.* [24] and Singh et al*.* [15].

3.5 Effect of Prescription Based Fertilizer Application on Neck Girth (cm) and Bulb Weight (gm) of Onion Crop

The data with respect to neck girth (cm) and bulb weight (gm) of onion crops were influenced significantly by the different nutrient management treatments (Table 6). The "neck girth" of an onion refers to the diameter or circumference of the neck portion of the bulb where the leaves emerge. The neck girth is an important indicator of onion quality, maturity and ultimately nutrient use efficiency.

Neck diameter varied significantly due to the different targets and the presence or absence of vermicompost and biofertilizer. The highest pooled neck girth (4.94 cm) was found in treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer which was statistically identical with treatment T_6- STCR target 350 q ha^{-1} without 5 t ha^{-1} Vermicompost + Biofertilizer (4.76 cm) where the lowest neck girth (3.23 cm) was found in absolute control treatment.

The pooled bulb weight ranges from 25.95 - 64.09 gm, however, the treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer showed the significantly higher bulb weight (64.09 gm) over all other treatments. This might be due to more translocation of photosynthates from leaves to bulbs and the solubilization effect of plant nutrients from vermicompost and biofertilizer [12]**.** Similar results with vermicompost and biofertilizer were reported by Datt and Kaur [25], Kumari et al*.* [26], Gour et al*.* [24] and Yogita and Ram [27].

Table 5. Effect of prescription based fertilizer application on polar diameter (cm) and equatorial diameter (cm) of onion crop

Tr. no	Treatments	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
		Polar Diameter (cm)				Equatorial diameter (cm)			
T_1	Absolute Control	4.10	3.59	3.88	3.86	6.76	5.67	6.14	6.19
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	4.87	4.36	4.60	4.61	7.42	6.40	7.10	6.97
T_3	As Per the Soil Test	5.51	4.89	5.00	5.13	8.29	7.12	8.00	7.80
T_4	STCR Target 250 q ha^{-1} without Vermicompost	5.00	4.52	4.62	4.71	7.63	6.78	7.21	7.21
T_5	STCR Target 300 q ha^{-1} without Vermicompost	5.87	5.00	5.24	5.37	8.67	7.20	8.24	8.04
T_6	STCR Target 350 q ha^{-1} without Vermicompost	6.57	5.65	6.21	6.14	9.94	8.13	9.15	9.07
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	5.22	4.68	4.87	4.92	8.10	6.97	7.45	7.51
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	6.34	5.49	6.10	5.98	9.24	7.82	8.91	8.66
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	6.89	5.83	6.35	6.36	10.22	8.33	9.89	9.48
T_{10}	Only Vermicompost 5 t ha^{-1}	4.76	4.13	4.49	4.46	7.10	6.10	6.87	6.69
SE m (±)		0.29	0.24	0.28	0.14	0.42	0.34	0.40	0.20
CD @ 5%		0.86	0.71	0.83	0.39	1.24	1.02	1.18	0.57

Table 6. Effect of prescription based fertilizer application on neck girth (cm) and bulb weight (gm) of onion crop

Tr. no	Treatments	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
		Neck Girth (cm)				Bulb Weight (gm)			
T_1	Absolute Control	3.57	2.98	3.14	3.23	24.37	20.55	32.93	25.95
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	3.88	3.60	3.71	3.73	53.76	40.46	64.26	52.83
T_3	As Per the Soil Test	4.14	3.89	3.98	4.00	54.99	41.68	66.56	54.41
T_4	STCR Target 250 q ha^{-1} without Vermicompost	3.97	3.65	3.80	3.81	47.55	38.67	57.71	47.98
T_5	STCR Target 300 q ha^{-1} without Vermicompost	4.37	4.00	4.18	4.18	58.39	43.29	68.28	56.65
T_6	STCR Target 350 q ha^{-1} without Vermicompost	4.96	4.50	4.83	4.76	65.18	45.83	75.09	62.03
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	4.00	3.71	3.84	3.85	56.03	42.59	67.45	55.36
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	4.78	4.38	4.57	4.58	60.94	44.28	72.13	59.12
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	5.13	4.73	4.97	4.94	67.66	46.17	78.43	64.09
T_{10}	Only Vermicompost 5 t ha^{-1}	3.81	3.41	3.67	3.63	29.44	24.36	45.27	33.03
SE m (±)		0.24	0.21	0.24	0.12	2.86	1.46	3.01	1.94
CD @ 5%		0.72	0.63	0.71	0.33	8.51	4.32	8.94	5.77

Table 7. Effect of prescription based fertilizer application on bulb yield (q ha^{-1})

Tr. no	Treatments	AICRP on STCR	PG Farm	AICRP on IWM	Pooled	Deviation in Bulb Yield (%)
T_1	Absolute Control	73.43	63.99	80.01	72.48	–
T_2	GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}	231.58	237.10	246.92	238.53	–
T_3	As Per the Soil Test	252.73	247.01	253.31	251.02	–
T_4	STCR Target 250 q ha^{-1} without Vermicompost	245.41	244.17	234.15	241.24	**-3.50**
T_5	STCR Target 300 q ha^{-1} without Vermicompost	310.25	296.03	311.93	306.07	**2.02**
T_6	STCR Target 350 q ha^{-1} without Vermicompost + Biofertilizer	357.24	347.61	342.33	349.06	**-0.27**
T_7	STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost	247.74	246.18	239.53	244.49	**-2.21**
T_8	STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost	326.89	321.00	314.26	320.72	**6.90**
T_9	STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer	365.90	358.56	366.54	363.67	**3.90**
T_{10}	Only Vermicompost 5 t ha^{-1}	130.39	121.25	117.71	123.12	–
SE m (±)		12.84	16.35	13.72	7.41	–
CD @ 5%		38.16	48.58	40.75	20.88	–

Table 8. Effect of prescription based fertilizer application on tops yield (q ha^{-1})

Tr. no	Treatments	AICRP on STCR	PG Farm	AICRP on IWM	Pooled
T_1	**Absolute Control**	13.52	13.67	14.68	**13.96**
T_2	**GRDF 100: 50: 50 N P_2O_5 K_2O Kg ha^{-1} + FYM 25 t ha^{-1}**	42.84	44.65	46.02	**44.51**
T_3	**As Per the Soil Test**	46.76	46.38	46.96	**46.70**
T_4	**STCR Target 250 q ha^{-1} without Vermicompost**	45.40	50.97	43.55	**46.64**
T_5	**STCR Target 300 q ha^{-1} without Vermicompost**	57.40	59.98	58.02	**58.27**
T_6	**STCR Target 350 q ha^{-1} without Vermicompost + Biofertilizer**	65.98	65.70	63.67	**65.12**
T_7	**STCR Target 250 q ha^{-1} with 5 t ha^{-1} Vermicompost**	45.83	46.53	44.44	**45.60**
T_8	**STCR Target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost**	60.48	60.30	58.09	**59.62**
T_9	**STCR Target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer**	67.48	65.95	68.00	**67.18**
T_{10}	**Only Vermicompost 5 t ha^{-1}**	24.12	23.80	21.91	**23.28**
SE m (±)		**2.38**	**3.21**	**2.54**	**1.45**
CD @ 5%		**7.06**	**9.55**	**7.55**	**4.06**

3.6 Effect of Prescription Based Fertilizer Application on Bulb Yield (q ha^{-1}) of Onion Crop

The data with respect to bulb yield (q ha^{-1}) of onion crops were influenced significantly by the different nutrient management treatments (Table 7).

Regarding pooled bulb yield, the application of fertilizer in treatment T_9 (STCR target 350 q ha^{-1} with 5 t ha^{-1} vermicompost + biofertilizer) resulted in a higher bulb yield (363.67 q ha^{-1}) compared to the control (72.48 q ha^{-1}) and the treatment with only vermicompost (123.12 q ha^{-1}). The utilization of vermicompost can potentially yield positive impacts on soil microbial populations and mycorrhizal activity, thereby facilitating nutrient solubilization. Additionally, the favourable C: N ratio of vermicompost contributes to enhancing the nutrient mineralization process in the soil [28].

Furthermore, the *Azospirillum* and *PSB* biofertilizers increase nutrient use efficiency by reducing nutrient losses, which ultimately enhances the vegetative and reproductive growth of onion crops. The pooled bulb yield of treatment T_6 (STCR target 350 q ha^{-1} without vermicompost + biofertilizer) at 349.06 q ha^{-1} was on par with treatment T_9.

It can be inferred that the yield target equation, derived from soil tests and crop responses, proved effective in attaining desired onion yields, whether used in conjunction with vermicompost or alone. Application of inorganic fertilizers guided by the targeted yield equation, combined with vermicompost and biofertilizer, resulted in higher onion bulb yields. This outcome could be attributed to the additional nutrient supplementation from vermicompost and improved nutrient availability through balanced fertilization, as demonstrated by Santhi et al. [29], Jadhav et al. [30] and Kokate et al. [31]. Similar results of yield target achieved in IPNS-based fertilizer application were reported by Tolanur and Badanur [32], Shrivas et al. [33], Singh et al. [34] and Dhruw et al. [35].

Deviation in Bulb Yield (%): The treatment T_4- STCR target 250 q ha^{-1} without Vermicompost, treatment T_6- STCR target 300 q ha^{-1} without Vermicompost + Biofertilizer and treatment T_7- STCR target 250 q ha^{-1} with Vermicompost were missing the target with 3.50, 0.27 and 2.21 % deviation. The treatment T_9- STCR target 350 q ha^{-1} with 5 t ha^{-1} Vermicompost + Biofertilizer, treatment T_8- STCR target 300 q ha^{-1} with 5 t ha^{-1} Vermicompost and treatment T_5- STCR target 300 q ha^{-1} without Vermicompost were observed additional increments of yield 3.90, 6.90 and 2.02 % respectively.

3.7 Effect of Prescription Based Fertilizer Application on Tops Yield (q ha^{-1}) of Onion Crop

The data presenting the top yield (q ha^{-1}) of onion crops as influenced by different treatments during the *rabi* season, 2022-23 are presented in Table 8.

The pooled top yield in treatments T_1- Control (13.96 q ha^{-1}) and T_{10}- only vermicompost application (23.28 q ha^{-1}) were noticed significantly lower over the rest of all other treatments. The treatment T_9- STCR target of 350 q ha^{-1} and 5 t ha^{-1} of vermicompost + biofertilizer achieved a significantly highest top yield (67.14 q ha^{-1}). This outcome can be attributed to the improved translocation of assimilates towards the sink. Application of N, P and K based on STCR equation with vermicompost and biofertilizer enhanced the nutrient metabolism, biological activity and growth parameter which encourage vegetative foliage *i.e.* top yield [31]. A similar target was achieved by Salunkhe et al. [36], Sekaran et al. [37], Singh et al. [34] and Dhruw et al. [35].

4. CONCLUSION

The growth parameters, including leaf number, plant height, chlorophyll content, diameter, neck girth and bulb weight exhibited significant increases in treatment T_9- STCR target of 350 q ha^{-1} along with 5 t ha^{-1} of vermicompost + biofertilizer. The bulb and top yields of *Rabi* onion indicated that treatment T_9 (STCR target 350 q ha^{-1} with vermicompost and biofertilizer) were significantly higher than all other treatments. The percentage achievement of the targeted yield in treatments T_9 and T_8 showed variances of 3.90% and 6.90%, respectively, at all locations, demonstrating the validity of the equations for prescribing *Rabi* onion. The fertilizer equations with vermicompost and vermicompost + biofertilizer can be recommended for *Rabi* onion grown in Inceptisols.

DISCLAIMER

Authors hereby declare that no generative AI technologies such as Large Language Models and text-to-image generators have been used during the writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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