Evaluation of STCR based targeted yield equations of *Amaranthus* (*Amaranthus tricolor* L.) in Southern Laterite Soils (AEU-8) of Kerala

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ABSTRACT

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A field experiment was carried out in the Instructional farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Thiruvananthapuram which comes under agro-ecological unit AEU-8 from the period March 2022 to June 2022 to test and validate the targeted yield equation for nutrient management developed by All India Coordinated research project on soil test based crop response studies (AICRP on STCR) 2014 for the cultivation of *Amaranthus*. The experiment was laid out in randomized block design with four replications and five treatment combinations *viz.,* T_1 as KAU organic POP, T_2 as soil test-based KAU, T3, T4, T5 as STCR based targeted yield recommendation for a target yield of 20, 22.5 and 30 tonnes respectively. Nutrient management with the application of STCR based targeted yield recommendation for a target yield of 25 tonnes T_5 showed a significant increase in plant height, stem girth, leaf length, petiole length, leaf width, number of branches plant^{-1}, number of leaves plant^{-1} and root length at 30 and 60 DAS respectively. This treatment, T_5 also improved the N, P and K content and their uptake by leaf, shoot and root respectively of *Amaranthus and* gave significantly better results for all parameters in comparison to other treatments. The equation of AICRP on STCR 2014 for the nutrient management for the cultivation of *Amaranthus* can be extended to the ultisols of AEU-8 of Thiruvananthapuram district of Kerala.

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Keywords: Amaranthus; STCR-based targeted yield equation; soil test-based recommendation; fertilizer; KAU POP; nutrient content; nutrient uptake.

1. INTRODUCTION

Vegetables form an indispensable part of the daily diet, particularly in India. Out of common leafy vegetables, amaranthus is the most popular vegetable consumed by people all over India [1] (Akbugwo *et al.,* 2007). It is a high-yielding nutritious tropical leafy vegetable. It is cultivated in an area of 1035 ha in Kerala [2] (Papachan and Divakar, 2012). This crop has been an attractive option for farmers because of its very short duration, high productivity, drought tolerance and relatively low incidence of pests and diseases. Amaranth is often referred to as poor man's spinach as it is a rich source of proteins, vitamins and minerals. It is short duration, quick response to manures and fertilizers, high yield, easiness in cultivation and wide adaptability to diverse agro-climatic situations makes it a favourite crop of farmers. Long-term studies indicated t soil fertility is decreased mostly due to excessive removal of nutrients and inadequate replenishment through manures and fertilizers. Appropriate application of fertilizers based on soil test nutrient availability and crop response to fertilizer applied for specific target yield seems to be a good option to achieve targeted yield seems to be a good option to achieve targeted food grain production as well as reducing environmental degradation. The soil test crop response approach of fertilizer application involved both soil and plant analysis on a scientific basis which proved to be a refined and unique technique for the most efficient use of fertilizer and soil nutrients. Several studies have documented the effects of soil test crop response-based fertilizer recommendation with integrated plant nutrient systems on soil nutrient status, soil organic carbon pools and potassium dynamics in soils. The soil test crop response approach derives a basis for precise quantitative adjustment of fertilizer and manure doses under varying soil test values and response conditions of the farmers and targeted levels of crop production. According to soil test crop response-based research experiment results showed a very close correlation between targeted yield and yield obtained and evidence of the use of soil testing within the limit of variation under field conditions. In this backdrop a field experiment was conducted to determine the effect of soil test crop response STCR) equation-based nutrient management approach on yield and nutrient uptake by *Amaranthus* (*Amaranthus tricolor* L.).

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2. MATERIAL AND METHODS

2.1 EXPERIMENTAL SITE

A field experiment was carried out in the Instructional farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Thiruvananthapuram from the period March 2022 to June 2022. Geographically, the study area is located at 8°5' N latitude and 76°9'E longitude and an altitude of 29 m above mean sea level located in the agroecological unit, AEU-8 of Kerala state, with the predominant soil type as the red loam of Vellayani series and belongs to the order ultisol. The soil of the experimental field was sandy loam in texture and acidic in reaction. The weather conditions that prevailed during the field experiment were a hot, humid, tropical climate. During the cropping period, the mean maximum atmospheric temperature varied from 30.70 to 33.41°C given in table-10. The corresponding mean minimum temperature of the location varied from 23.4 to 27.6°C. The relative humidity was recorded between 89.23% and 90.17% during the crop-growing period. Rainfall received during the crop growing period was 525 mm. The experiment was laid out in a randomized block design with four replications and five treatment combinations for nutrient management. The treatments T_1 and T_2 were Package of practice recommendations of Kerala Agricultural University for organic and conventional agriculture. STCR-based recommendations for a target yield of 20, 22.5 and 25 tonnes formed the treatments T_3, T_4 and T_5 respectively. Standard crop production practices and methods were followed for weeding, fertilizer application and crop protection management to grow the crop. Based on the soil test values of samples collected before the crop and considering the nutrient status of recommended doses of manures applied, fertilizer doses for STCR-based targeted yield were calculated using the Targeted yield equation for *Amaranthus.* The initial soil properties are given in table 1.

Fertilizer prescription equations for yield targeting in *Amaranthus tricolor*

1. **With FYM**

$$FN = 3.50\,T - 0.10\,SN - 0.19\,ON$$
$$FP_2O_5 = 1.44\,T - 2.58\,SP - 0.30\,OP$$
$$FK_2O = 1.35\,T - 0.06\,SK - 0.13\,OK$$

T were = Targeted yield

FN	= Fertilizer Nitrogen dose
SN	= Nitrogen contribution of Soil
ON	= Nitrogen contribution of Organic sources
FP_2O_5	= Fertilizer Phosphorous dose
SP	= Phosphorous contribution of Soil
OP	= Phosphorous contribution of Organic sources
FK_2O	= Fertilizer Potassium dose
SK	= Potassium contribution of Soil
OK	= Potassium contribution of Organic sources

2.2 Data collection

Five plants were selected as representative plants from each plot for measurement of yield parameters like leaf-to-stem ratio at 30 DAS, total yield plant^{-1} and total yield plot^{-1}. For each treatment, the mean value of the data collected from five plants was calculated for respective biometric observation. The leaf-to-stem ratio at 30 DAS, total yield plant^{-1} and total yield plot^{-1} were measured respectively. The soil was dried by air drying, crushed, and sieved using a 2 mm sieve before being stored in an airtight container for N, P and K in soil by using standard methods as outlined in the table.2. Sampled leaf, shoot and roots of samples were dried in a hot air oven at 105^{o}C to a constant weight and ground into a fine powder for analysis of N, P and K content of respective parts using standard procedures. For the estimation of N single acid digestion was performed using sulphuric acid. For the estimation of other nutrients diacid digestion was performed using concentrated perchloric and nitric acid.

2.3 STATISTICAL ANALYSIS

Statistical analysis was done by using the software grapes created by [3] Gopinath *et al*. (2021). Statistical analysis for yield parameters was performed based on the average data from five plants per treatment plot. The data recorded for post-harvest soil and the plant samples from each plot were statistically analyzed.

3. RESULTS AND DISCUSSION

3.1 EFFECT OF TREATMENTS ON YIELD AND YIELD ATTRIBUTES

Analysis of data shows that different treatments have significant effects on yield attributes *viz., the* leaf-to-stem ratio at 30 DAS, total yield plant^{-1} and total yield plot^{-1} of *Amaranthus* (Table 2). The maximum values of leaf-to-stem ratio at 30 DAS, total yield plant^{-1} and total yield plot^{-1} were obtained from treatment T_5 (STCR-based targeted yield recommendation for a target yield of 25 tonnes). The reason behind the improvement in yield attributes might be due to the availability of a sufficient amount of plant nutrients to crop which resulted in better uptake of nutrients, plant vigour and improved yield. It was observed that not only the increased availability of nutrients increased the yield attributes but with an increase in the fertilizer application there might be an increase in the dry matter and increased growth components due to improved fertilizer levels which gave stability in a higher supply of photosynthates towards the sink (number of leaves plant^{-1}). As a result, all the yield attributes of *Amaranthus* increased significantly. The improvement in yield (leaf and shoot) might be due to an improved nutritional environment in low status of N and K soil through an increased supply of major nutrients which increases their uptake by plants and this led to enhanced growth and yield attributes, which ultimately resulted in increased yield of the crop. [4] Kumari *et al.,* (2022) reported similar observations in wheat.

3.2 INFLUENCE OF TREATMENTS ON N, P AND K AVAILABILITY

The effect of the STCR equation on available N, P and K is presented in Table 3.

Available N

The available N was significantly increased with the integrated application of chemical fertilizers and FYM calculated based on the STCR-based targeted yield equation developed. The highest amount of available N was noticed in treatment T_5 where 25 t ha^{-1} yield of *Amaranthus* was targeted and also the integration of chemical fertilizers and FYM was made. The availability increased as the STCR fertilizer dose was increased. The available N after harvest varied from 232 (T_1) to 374 (T_5) kg ha^{-1} in comparison to the initial available N content of the soil (119 kg ha^{-1}). There was a significant difference between all the treatments. Organic manure, such as FYM, when combined with other nutrients, improved nutrient mineralization and as a result, increased available nutrient status in the soil. This efficiently supplied a balanced nutritional environment in both the rhizosphere and the plant system, resulting in better mineralization by soil microorganisms, which increased the available N in the soil after crop harvest as similar observations were also reported by [5] Dwivedi *et al.* (2016) and [6] Jakhar *et al.* (2018).

Available P

The available P in post-harvest soil ranged from 49.67 (T_1) to 78.87 kg ha^{-1} (T_5). The initial available P was found to be 24 kg ha^{-1}. There was a significant difference between all the treatments. P may be more readily available in the soil as a result of the production of organic acids during FYM decomposition, which speeds up mineralization [7] (Dhakal *et al.,* 2016). By solubilizing and mobilising native soil fixed P, the combined action of FYM with P fertilisers increases soil available P [8] (Amruth *et al.,* 2018) and thus the availability of P from organic manures such as FYM can be increased to all phases of crop growth [9] (Parihar *et al.,* 2013).

Available K

The available K in soil samples ranged from 78.70 to 127.99 kg ha^{-1}. The available K in the initial sample was 213 kg ha^{-1}. It was noted that there was a rise in soil-available K along with an increase in yield target levels. The addition of FYM to inorganic fertilisers may boost the soil's CEC, which was responsible for retaining more exchangeable K and thereby increasing the availability of K [10] (Binjola *et al*., 2017) too reported similar results. The NPK fertilisers, in combination with FYM, boosted soil available K status by lowering K fixation due to organic matter interaction with clay, as well as directly adding to the available pools of K in the soil [11] (Tomar *et al*., 2018).

3.3 INFLUENCE OF TREATMENTS ON PRIMARY NUTRIENT UPTAKE BY CROP

The highest uptake of primary nutrients and highest yield were observed in T_5. In the current experiment, T_5 (targeted yield 25 t ha^{-1} based STCR treatment) exhibited the highest total N, P and K uptake, with values of 48.05, 6.13 and 45.74 kg ha^{-1} respectively. It showed that as yield targets were increased, total N, P and K uptake increased. All of the STCR treatments had significantly greater total N, P and K uptake than the other treatments, which could be attributed to increased nutrient content and total yield [12] (Chandrakanth, 2015). The ability of a plant to take up nutrients depends on the amount of nutrients that are present in the soil. The amount of nutrients that can be effectively removed from the soil under particular instances can also be thought of as a factor in crop yield. Therefore, higher dry matter production can be connected to increased nutrient uptake. The maximum dry matter production and nutrient uptake were both recorded by the treatment T_5. By applying vermicompost, the rate of metabolic activity and the rate of cell division is boosted. This led to a higher uptake of nutrients, which may have boosted nitrogen uptake as observed by James et al., 1967. To get optimum yields of these crops, NPK fertilisers must be used in a balanced way. The reactions to N are more obvious in vegetable crops like Amaranthus. However, P and K are also necessary for the growth of high-quality vegetables. These results reveal that the fertilizer application can have a direct effect on nutrient uptake and thereby improve the yield of the crop as long as the supplied nutrient is well within the optimum range of the crop as suggested in the Mistcherlich equation. Observations of this tune were also made by [13] Swadija (1997), [14] Nagarajan (2003), [15] Cheraghi *et al.* (2012) and [16] Barker (2012).

4. CONCLUSION

The highest dry matter production was achieved in T_5 which suggested that judicious application of fertilizers can give a positive response to the yield of the crop. The crop responded positively to higher fertilizer doses in T5 which is reflected in the results obtained while analyzing the nutrient content of the crop and the nutrient uptake studies. There was a significant difference between the treatments when the plant Ca, Mg and micronutrient content was studied. The nutrients were maintained in a sufficient range. While considering the economic aspect too, T_5 showed superiority over the treatments. It can be concluded that the STCR-IPNS-based targeted yield equations for (*Amaranthus tricolor*. L) can be adopted in AEU-8 of Thiruvananthapuram district of Kerala as the yield targets can be achieved with optimum use of fertilizers and manures without compromising the soil quality and yield.

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Comment [WU6]: Reform all reference as per journal guideline

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Table no 1: Initial properties of the soil before experimentation

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Initial properties of soil	**Content**	**Remarks**
Sand (%)	63.01	
Silt (%)	13.82	Sandy clay loam
Clay (%)	22.67	
Available N (kg ha^{-1})	219.16	Deficient
Available P (kg ha^{-1})	14.04	Medium
Available K (kg ha^{-1})	113.67	Deficient

Table no 2: Influence of treatments yield parameters of the crop at harvest

Treatments	Yield parameters		
	Leaf-to-stem ratio at 30 DAS	Total yield per plant (g plant^{-1})	Total yield per plot (t ha^{-1})
T_1	2.02±0.05^{c}	85.51±4.89^{e}	9.53±0.55^{e}
T_2	2.26±0.17^{bc}	129.19±6.87^{d}	14.40±0.77^{d}
T_3	2.95±0.17^{a}	174.68±25.30^{c}	19.47±2.82^{c}

T_4	2.73±0.31[ab]	196.84±4.52[b]	21.94±0.50[b]
T_5	2.97±0.22[a]	222.41±3.21[a]	24.79±0.36[a]
SE (m)	0.16	6.77	0.75
CD	0.49	20.85	2.32
CV (%)	12.23	8.37	8.37

Table no 3: Influence of treatments on N, P and K availability of soil after crop harvest

Treatments	Available Nutrients (kg ha^{-1})		
	N	P	K
T_1	232.95±31.50[e]	56.97±1.70[d]	78.70±6.07[e]
T_2	273.24±5.65[d]	49.67±1.57[e]	89.59±0.27[d]
T_3	313.53±2.02[c]	64.27±1.90[c]	111.59±6.07[b]
T_4	353.82±29.44[b]	71.57±7.78[b]	109.19±6.44[c]
T_5	374.11±32.43[a]	78.87±1.87[a]	127.99±10.18[a]
SE (m)	12.02	2.13	3.50
CD	37.03	6.57	10.78
CV (%)	7.67	6.64	6.06

Table no 4: Effect of treatments on N, P and K uptake by crop

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Treatments	Total nutrient uptake (kg ha^{-1})		
	N	P	K
T_1	22.23±1.05[e]	3.33±0.27[e]	15.04±0.90[e]
T_2	28.28±1.39[d]	4.03±0.15[d]	25.68±0.74[d]
T_3	34.33±2.26[c]	4.73±0.23[c]	30.71±0.57[c]
T_4	40.43±3.06[b]	5.44±0.70[b]	38.98±4.20[b]
T_5	48.05±3.84[a]	6.13±0.38[a]	45.74±3.80[a]
SE (m)	1.35	0.20	1.14
CD	4.16	0.62	3.52
CV (%)	7.80	8.52	7.31