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Comparative assessment of popular turmeric cultivars in coastal zone of south 24 Parganas district of West Bengal under STI technique

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Abstract
An experiment was carried out with important cultivars of turmeric (*Suranjana, Suvarna, Suguna* and local cultivar) during 2015-16 to 2017-18 to identify the superior cultivar under "STI"- Sustainable Turmeric Initiative technique and quantification of curcumin content using HPTLC standard protocol. The test cultivars showed variability in respect of their growth characters, production potentiality and quality aspects. The study reflected that the incorporation of high quantum of nutrients along with organic manures under STI technique might fulfill the nutritional demand and effectively increased the yield and quality of these promising cultivars. The experiment revealed that *Suranjana* exhibited maximum plant height (88.1 cm), number of leaves/plant (7.7), average weight of rhizome per plant (873 g) and curcumin content (19.96 mg/g). Higher B:C ratio reflected with the yield performance and key quality aspects *Suranjana* cultivar was found as a good alternative to the local cultivar practiced by the farmers of South 24 Parganas district. The other three cultivars were also found superior over the traditional cultivar in respect of yield attributing characters and curcumin contents.

Keywords: Comparative assessment, turmeric cultivars, STI technique

Introduction
Turmeric (*Curcuma longa* L.), an ancient and sacred spice of India known as 'Indian saffron' or 'Golden spice', is a rhizomatous herbaceous perennial flowering plant of family Zingiberaceae, native to the Indian subcontinent and Southeast Asia. Nearly in all the states of India, turmeric is cultivated mainly as spice, whereas the growing medicinal and cosmetic industries in India generates higher profitability through this crop. West Bengal is one of the important traditional turmeric growers stood 7th among the major turmeric producing states of India (Anonymous 2017) [2]. The main active bio-chemical compound "Curcumin" present in rhizome is the main source of attraction for the cosmetic and medical industry. Turmeric oleoresin, obtained by organic solvent extraction of turmeric, is a brownish-orange viscous oily product containing 30 to 55% curcuminoid pigments and 15 to 25% volatile oil (Souza and Gloria 1998) [15]. Several researchers elaborated the anti-inflammatory, anti-mutagen, anticancer, antibacterial, anti-oxidant, antifungal, anti-parasitic and detox properties (Hermann and Martine 1991, Osawa *et al.*, 1995, Sugiyama *et al.*, 1996, Nakamura *et al.*, 1998) [7, 13, 16, 12] of the curcumin. Turmeric can grow in diverse climatic condition but prefers warm and humid climate. Local climatic and edaphic factors are important to achieve quality yield (Akamine *et al.*, 1995, Ishimine *et al.*, 2003) [1, 11] adopting modern scientific management practices. Hossain *et al.*(2009) [9] reported that better curcumin content can be achieved with higher light intensity, though it was proved that it can be cultivated well at around 59-73% RLI (Relative Light Intensity).

The climatic condition of the South 24 Parganas is quite conducive to commercial cultivation of turmeric. But in spite of the favourable agro-climatic conditions, production level is low mainly due to lack of high yielding verities and proper package of practices. Cultivars are the chief factor for getting quality yield; recent studies revealed that replacement of suitable agro-ecologically adaptable cultivars can yield much better than the traditional one. The introduction of cultivars having the potential to utilize the nutrient in sufficient quantum to achieve the high rhizome yield with greater quality is the important solution for successful turmeric cultivation. Moreover, the systematic efforts on introduction and evaluation of improved cultivars of turmeric is very much important to explore the potentiality for particular agro-ecological situation. In this context, the incorporation of modern cultivation practices is very much required to achieve the higher quality yield with financial betterment.

Considering the beneficial aspects, a modern scientific cultivation technique i.e. STI- Systemic Turmeric Initiative has been tried along with the promising cultivars. The "STI" technique, the scientific management practices includes optimum spacing, specific rhizome size and balanced fertilization with organic resources might be helpful to augmented the yield and quality of the improved cultivars of turmeric. The conjugated use of organic and inorganic nutrient sources not only increases the yield and quality but also improves the soil health. The organic source will help to maintain nutrient equilibrium in soils whereas, the inorganic fertilizers readily furnish nutrient which would enhance the initial growth in the crop and finally results in better growth, quality and yield. In South 24 Parganas district though turmeric are grown widely but most of the growers used to cultivate few decades old traditional cultivars without adopting any scientific practices and resulted lower yield with poor quality. Keeping all the factors under consideration, an attempt has been made to assess few promising popular cultivars in South 24 Parganas district with an objective to replace the traditional cultivars following "STI"- Sustainable Turmeric Initiative technique.

Materials & methods

Field experiment

Three promising turmeric cultivars (*Suguna, Suvarna and Suranjana*) and one local cultivar were evaluated for yield and quality performance under field condition adopting "Sustainable Turmeric Initiative" (STI) technique at Instructional Farm of Sasya Shyamala Krishi Vigyan Kendra, Arapanch, South 24 Parganas district (Latitude: 22°26'27.15"N; Longitude: 88°25'28.69"E) during summer months for three consecutive seasons (2015-16 to 2017-18). The whole experiment was laid in Randomized Block Design (RBD) with five replication. The beds were prepared at 15 cm in height and 120 cm in width, and a convenient length – with at least 30 cm spacing between the beds. Healthy finger and mother rhizomes of all cultivars with well developed buds sorted accordingly for planting. Treated rhizome weighing 20 to 35 grams each (single rhizomes having a length of 7 to 9 cm, and a perimeter of 7 to 8 cm) with carbendazim @ 2.5 g/l water was planted in 40 x 30 cm distance between row to row and plant to plant respectively, at a depth of 4.5 cm. Planting was done during the month of April-May. Farmyard Manure (FYM) enriched with *Trichoderma viride* @ 15 t/ha along with full dose of recommended $N:P_2O_5:K_2O$ @ 120:60:60 kg/ha was given in two equal splits doses for N and K (as basal and side dressed after thirty days of sowing) and entire amount of P was applied as basal dose. NSKE 10,000 PPM @ 3ml/l has been sprayed twice to protect the biotic stress. Observations were recorded on growth parameters such as plant height (cm), number of leaves per plant, yield parameter such as rhizome weight per plant (g), yield (t/ha) at after harvest. Curcumin content of the rhizome were evaluated for all cultivars using HPTLC standard protocol described by Das *et al.* (2017) [4]. Recorded data were statistically analyzed through Duncan Multiple Range Test (DMRT) using IBM-SPSS software version 20.0.

HPTLC standard protocol followed

High performance thin layer chromatographic (HPTLC) analysis was carried out on a HPTLC plate pre-coated with silica gel. Samples (10μl) and standards (10-25 μl) were applied on plates by Linomat 5 applicator (Camag, Switzerland). The plates were developed to a distance of 90 mm in Camag twintrough chamber with mobile phase of Petroleum ether: Acetone (70:30) in 27°C for 25 min. Afterwards, the plates were scanned for densitometry analysis in CAMAG TLC scanner (Camag, Switzerland) at λ_{max}=450 nm. The band curcumin in the samples was confirmed by comparing R_f values and spectra of the band with that of the standard (Figure 4, 5, 6). Quantification of curcumin concentration was done by five point standard curve (Y=-441.442 + 4.035x; R^2= 0.995). The chromatograms were finally integrated using Win CATS 4.0 computer programme.

Results & Discussion

It is apparent from the present data (Table 1) that the cultivars under evaluation showed significant difference among each other. The result reflected that highest plant height was obtained by the cultivar *Suranjana* (88.1 cm), which was significantly different from the other cultivars; followed by *Suguna* (77.6 cm), *Suvarna* (72.6) and the local cultivar (68.9). *Suranjana* cultivar also registered significantly higher numbers of leaves (7.7) as compared to the local cultivar (6.4); whereas no significant difference was found among the cultivars *Suranjana, Suguna and Suvarna*. Seed rhizome is the key input for the root crops and its weight per plant governs the yield of turmeric. Highest rhizome weight per plant was also recorded in cultivar *Suranjana* (873 g), being statistically at par with the cultivar *Suvarna* (817 g). It is lucid to record that the application of integrated nutrient management significantly influenced the cultivars *Suranjana, Suguna and Suvarna* in respect to turmeric yield as compared to local cultivar. It was found that the cultivar *Suranjana* achieved highest yield (46.4 t/ha) under STI method. Whereas, local cultivar recorded significantly lowest yield (31.40 t/ha) (Table 1). Thus it might be assumed that the fertilization under STI practices (NPK@120:60:60 kg/ha +15t/ha FYM) effectively fulfill the total nutritional requirement to the crop which was reflected from better growth and yield. Especially N and K are two important nutrients for boosting the growth and yield of turmeric. B:C ratio was also significantly higher on cultivar *Suranjana* (2.84) followed by cultivars *Suguna and Suvarna* and local cultivar (1.61). Thus it might be assumed that the fertilization under STI practices (NPK@120:60:60 kg/ha +15 t/ha FYM) effectively fulfill the total nutritional requirement to the crop which was reflected from better growth and yield. The local cultivar cultivated showed the inferior quality in terms of yield attributing characters under modern STI techniques as compared to three improved cultivars viz. *Suranjana, Suguna and Suvarna*. This finding proved that the performance of local cultivar in respect of the nutrient utilization to achieve higher yield was not significantly at promising level as compared to the other cultivars. It might be resulted from the fact that the local cultivar didn't have the potentiality to utilize the nutrients as per the requirement resulting the lower performance in comparison to *Suranjana* cultivar. But the cultivar *Suranjana* successfully utilized the nutrients throughout its growth and yield period. It is prominent from the present investigation that as all the cultivars are evaluated under STI techniques followed by recommended dose of fertilizer; so cultivars characters are the chief factor for the differential response obtained in respect of growth characters. Variation of growth characters induced by cultivars is also documented by Chaudhary *et al.* (2006) [3], who reported that the variation in the yield among the test turmeric cultivars grown under the same agro climatic condition can be attributed to genetic factor. Hikmat *et al.* (2012) [8] found that high genotypic coefficient of variation was depend on initial weight of rhizome, and wet rhizome yield per plant. In our present findings we also assessed the relationship between the principle growth characters (plant height, leaf numbers and rhizome weight) and yield through linear regression model; which shows that leaf number and rhizome weight are highly related with the yield of turmeric (90.5% and 98.2%, respectively); while only 59.5% association between plant height and rhizome yield is obtained (Figure 1, 2, 3). All the growth characters were significantly correlated with the yield. Our result can be correlated with the findings of Singh and Prasad (2006) [14].

Table 1: Comparative performances of different cultivars on yield attributing characters

Cultivars	Plant Height (cm)	No. of leaves/plant	Rhizome weight (g)	Yield (tonne/ha)	B:C ratio
Local	68.9 ± 2.3^{c}	6.4 ± 0.277^{b}	685 ± 11.6^{c}	31.4 ± 1.23^{c}	1.61 ± 0.0586^{c}
Suranjana	88.1 ± 2.61^{a}	7.7 ± 0.378^{a}	873 ± 24.5^{a}	46.4 ± 1.63^{a}	2.84 ± 0.0699^{a}
Suguna	77.6 ± 2.06^{b}	7.2 ± 0.249^{ab}	749 ± 23.6^{b}	38.2 ± 0.85^{b}	2.39 ± 0.0733^{b}
Suvarna	72.6 ± 1.75^{bc}	7.2 ± 0.221^{ab}	817 ± 18.9^{a}	43.1 ± 1.54^{a}	2.59 ± 0.132^{ab}

*Values in column followed by different letter significantly different at P=0.05 (DMRT test)

Table 2: Correlation of yield attributing characters with yield

Characters	Plant height (cm)	No. of leaves/plant	Rhizome weight (g)	Yield (tonne/ha)
Plant height	1			
No. of leaves/plant	0.501*	1		
Rhizome weight	0.645**	0.622**	1	
Yield	0.645**	0.528*	0.755**	1

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed)

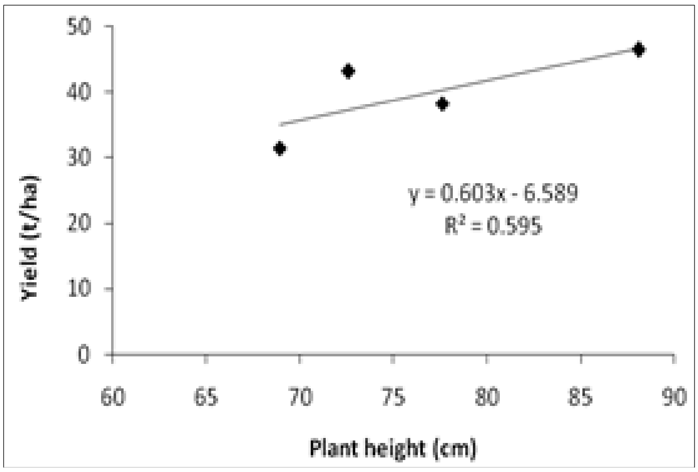

Fig 1: Regression between plant height (cm) and yield (t/ha)

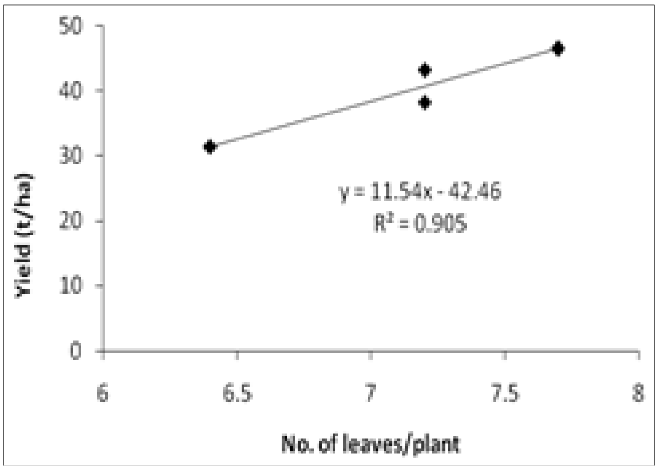

Fig 2: Regression between leaf numbers and yield (t/ha)

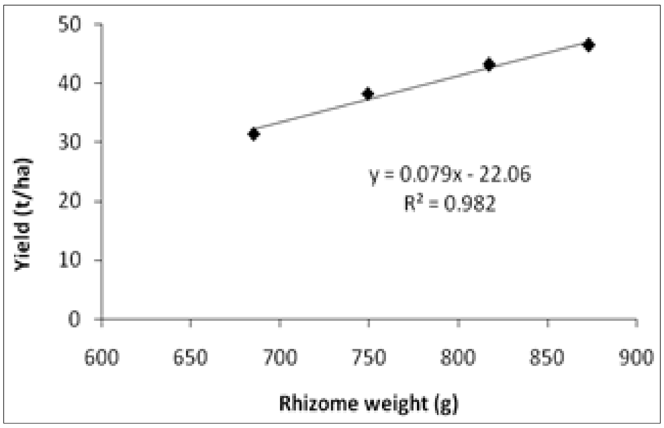

Figure 3: Regression between the rhizome weight (g) and yield (t/ha)

Estimation of curcumin content

Turmeric contains a yellow-pigmented fraction that mainly consists of curcuminoids. The principal ingredient of curcuminoids is curcumin. Curcumin [1,7-bis (4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione] is a naturally occurring polyphenolic phytochemical (Ireson *et al.*, 2002, Heath *et al.*, 2003) [10,6]. Significant differences in curcumin content were observed in the cultivars cultivated under STI practices.

Several researchers concluded that curcumin content of turmeric is closely dependent on the nutrient management practices. Incorporation of the organic manure significantly improved the turmeric quality in respect of the curcumin content. Our result is in line with the findings of Velmurugan *et al.*(2008) [17] and Gill *et al.* (1998) [5]. The highest quantity of curcumin was observed in the cultivar *Suranjana* (19.96 mg/g) followed by *Suguna* (18.13 mg/g) and local ones (17.87 mg/g) (Table 3). The findings indicated that the *Suranjana* cultivar responded effectively under the integrated nutrient management and accelerated its curcumin content as compared to other cultivars.

Table 3: Evaluation of the performance of different cultivars on production of curcumin

Cultivars	Curcumin Content (mg/g)
Suranjana	19.96±0.84
Suguna	18.13±0.12
Suvarna	12.34±0.37
Local	17.87±0.10

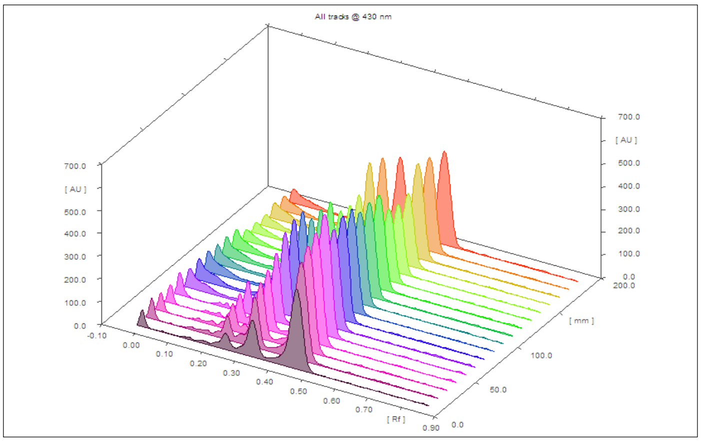

Fig 4: HPTLC densitogram at 457 nm in the order of standard-curcumin (track 1 to 5); Cultivar *Suranjana* (track 6-8); Cultivar *Suguna* (track 9-11); Cultivar *Suvarna* (track 12-14) and Local traditional cultivar (track 15-17)

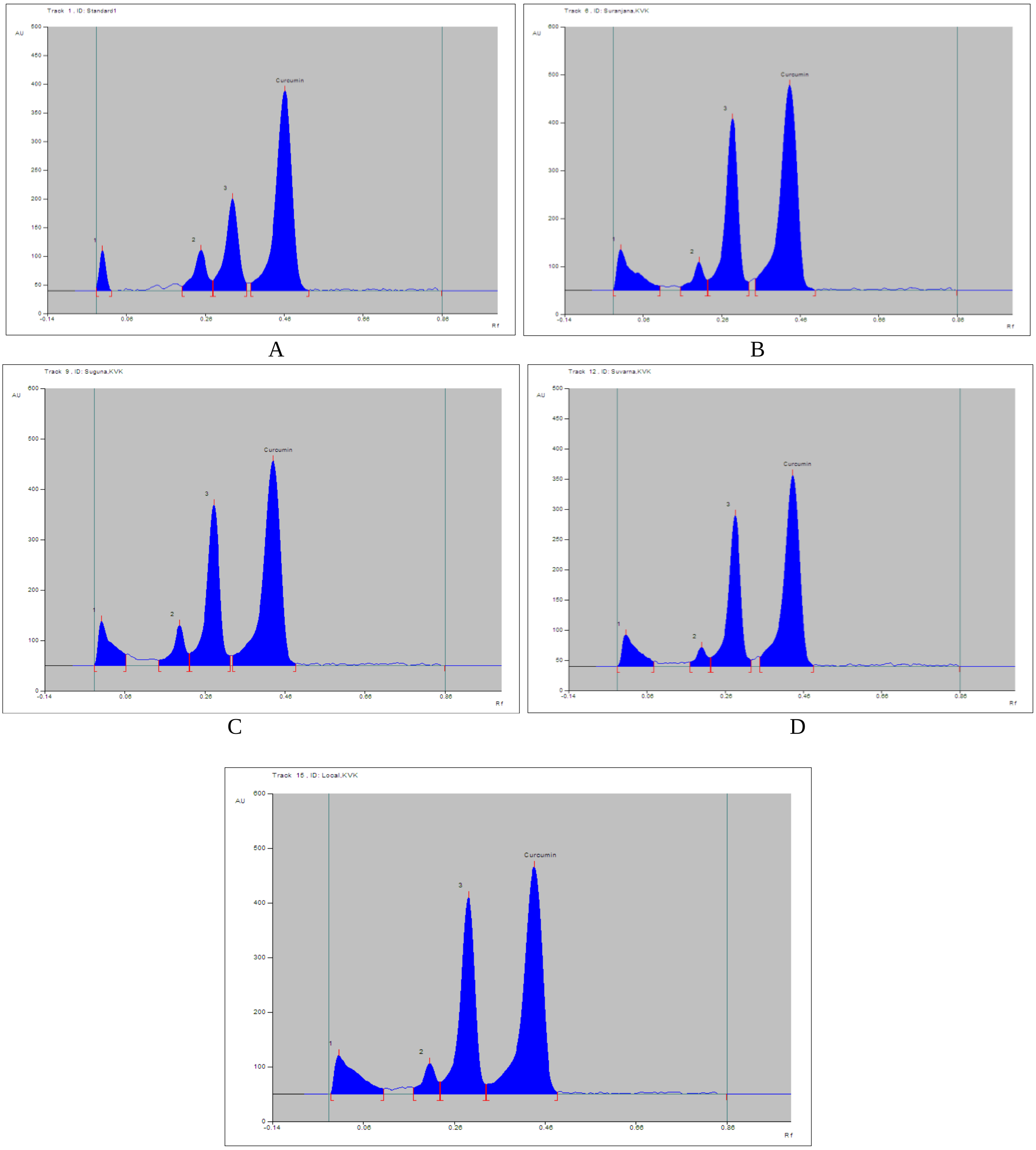

Fig 5: HPTLC Chromatograms of curcumin - A) Standard curcumin; B) Cultivar Suranjana; C) Cultivar Suguna; D) Cultivar Suvarna and E) Local Cultivar

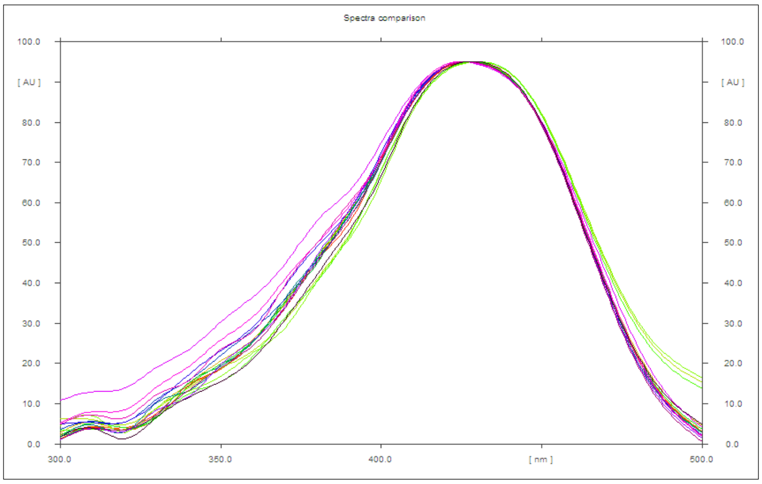

Fig 6: Spectra of standard Curcumin (Pink), *Suranjana* (Blue), *Suguna* (Green), *Suvarna* (Yellow) and *Local* (Orange) cultivars

From different studies it was observed that the application of organic nutrient sources increased the curcumin content in different extents. Application of recommended dose of fertilizer along with organic manures influence the bio-chemical parameters as documented; specific genetic characters possessed by individual cultivars influence the plant characters. Thus in our present study it is revealed that under same condition the test cultivars showed increasing curcumin content.

Conclusion

From the study it was revealed that out of four different cultivars evaluated for higher quality yield under STI technique, *Suranjana* was found as most potent cultivar over others. Thus, it may be concluded that the adaptation of *Suranjana* cultivar followed by STI management practice may be advantageous to the farming community of South 24 Parganas District to achieve the higher quality yield with greater profitability.

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