CHAPTER 4

AGRICULCUTURE AND OTHER APPLICATIONS

VETIVER SYSTEM FOR SOIL AND WATER CONSERVATION IN TEA PLANTATIONS INCLUDING SELECTION OF APPROPRIATE PLANTING MATERIAL AND OTHER APPLICATIONS

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ABSTRACT:

During 1990s Vetiver was introduced in tea plantations of Tata Tea Limited in High Range (Kerala) and Anamallais (Tamil Nadu) in South India for preventing soil erosion and moisture conservation by the R&D Department of the Company. The progress made during the past 15 years is outlined in this article. None of the cultivars tested produced viable seeds. Out of the 27 cultivars tested, cultivars 'Madupatty' and 'Silentvalley' and ODV-3 from Aromatic and Medicinal Plant research station, Odakkali of Kerala Agricultural University, are vigorous growers and were found to be highly promising for soil and moisture conservation in Tea plantations. Cultivar 'Pannimade' was found to be tolerant to partial shade. The oil content in the roots of 'Maduaptty' was low and this was found to be beneficial in that problem of harvesting roots for oil by anti social elements could be avoided. The cultivar 'Silentvalley' and ODV -3 are equally vigorous when compared to 'Madupatty' and 'Pannimade'. The cultivar 'Silentvalley' registered the highest percent of good quality oil followed by ODV-1 and ODV-2.

Under the hilly tracts of South India, Vetiver nursery could be established by planting 25 to 30 cm long tillers separated from well-grown clumps. The tillers were planted in 10 cm deep pits at a spacing of 60 cm. Irrigation was carried out during the dry spell to enhance vigorous growth. A mixture of 1:1 NP was used to give 40 kg NP/ha. to enhance vigor of the plants. Cutting encourages 'tillering' and produced more planting material in a short period. An average of 50 to 60 tillers could be generated in 12 months period under climatical conditions prevailed. The growth in Anamallais was found to be superior to that of High Range.

Vetiver System could be effectively used in tea plantations for soil and moisture conservation and a live edge of Vetiver could be established in place of stone revetments. Twenty five to thirty cm long tillers separated from well-grown clumps are to be planted at a spacing of 15-20 cm in order to form a thick hedge in areas where it is desired. Only a single row of tillers, three per pit, need to be planted. Once the hedges are established the only care needed is trimming, 2 or 3 times per annum to a height of about 30 cm. The biomass generated from these plants serves as an excellent mulching and thatching material in tea plantations. The cut leaves when used mulch in new clearings, it prevented weed growth for 5 months and retained sufficient moisture for young tea plants. The live hedge of Vetiver enhanced moisture retention capacity in the site of planting and served as a live barrier for soil conservation. Vetiver grows so densely that it can block the spread of other grasses including some of the world's worst creeping grasses. Vetiver is highly sensitive to Glyphosate and utmost care should be

taken while using this herbicide. Wild animals such as elephants, deer and gaur do not relish mature foliage of Vetiver. However, animals relish tender leaves.

Other applications made are improving quality of water by floating Vetiver and growing Vetiver on the beach of a resort hotel to prevent beach erosion.

The beach in front of the resort near Chennai (Tamil Nadu) has been eroding into the sea. In order to prevent erosion, experimental planting of Vetiver (ecotype - Madupatty) was undertaken in July 2006. Three rows of Vetiver were planted at a spacing of 22 cm between the plants in the row and 1 m between the rows. The total area covered was 4 kms. The hedges were well established by end October. It was also found necessary to trim the plants once in two months because of vigorous growth. It was proved that Vetiver could be grown successfully to prevent sea erosion in coastal areas.

Vetiver has made significant inroads in the minds of professionals around the world who several year back scoffed at the idea of a grass with a Tamil name and indigenous to India could be used to partly replace mechanical engineering works, could have multiple environmental application and could offer inexpensive and reliable solutions to soil degradation, loss of soil fertility, ground water recharging, water quality enhancement and site rehabilitation in relation to industry and intensive commercial agriculture.

1. INTRODUCTION

Soil erosion and consequent loss of water have been recognized as the most serious agricultural problem all over the world. Few resource problems are so important and so little publicized, as the disappearance of soil from our land. Each year millions of tons of soil is washed away to the rivers and sea by erosion. There is no way we can replace this soil. Soil erosion is a quiet crisis, largely man made disaster that is unfolding gradually. The changes it brings are chronic and irreversible viz, lost land, reduced productivity of farms, plantations and forests, silted rivers, reservoirs, canals and irrigation works, washed out roads, bridges and destroyed agricultural land where myriad valuable micro-organisms would normally breed and prosper. Soil erosion is getting worse in warmer parts of the world. The swelling population, poor land management, vulnerable soils and hostile climates add up to lethal combination that fosters erosion bringing with it environmental degradation, rising deforestation and erratic water supplies. The world’s forests are disappearing 30 times faster than they are being planted. Such immediate and far reaching consequences have led to its recognition in almost all countries as one of the most serious agricultural problems of the world. Suffice to say, soil erosion is literally costing the earth. It is with this scenario in mind that many people around the world who were concerned about the environmental problem became intrigued by the ideas of a couple of world Bank Agriculturists, Richard Grimshaw and John Greenfield. These two had an entrancing vision; a little known grass called **Vetiver**, they proposed, could provide the answer to soil erosion - and it could do so in a way that would appeal to millions of farmers, land owners, politicians and administrators.

2. HISTORICAL ASPECTS

There are many soil conservation measures but the most outstanding of these is the use of vegetative soil and moisture conservation measures that are cheap, replicable, sustainable and fully effective in stopping erosive degradation and increasing crop yield. The use of vegetation as a bioengineering tool for erosion control and slope stabilization has been implemented for centuries but its popularity has increased in the last few years. Many studies all over the world have shown that Vetiver as a hedge is the ideal plant to conserve soil and rehabilitate eroded land. This grass has been used for soil and water conservation in agricultural lands for many years but its related impact on land stabilization, soil erosion and sediment control only started in the late 1980s following its promotion by the World Bank.

In the early part of last century the sugar industry had recognized the value of Vetiver grass for conservation purpose and it was used in the West India and South Africa for this purpose. Although the sugar industry has used Vetiver grass as a vegetative soil conservation measure in isolated parts of the world for the past 60 years, it has gone unnoticed by researchers, even in the same countries. Strangely, it has never been a subject for any research. Yet over 200 years, it has been used by farmers in India as a permanent hedge. It has been free of problems and dense enough to effectively filter silt out of runoff.

Vetiver belongs to grass family, Gramineae as rice, maize and sugarcane. Its botanic name is *Vetiveria zizanioides* L. (Nash). The generic name comes from "Vetiver" its name in Tamil meaning "root that is dug up". The specific name "zizanioides" means 'riverside' which reflects the fact that in the remote past the plant was commonly found in the riverbanks along the waterways in India. Recently it was renamed as *Chrysopogon zizanioides* L. (Roberty). The plant is native to India where it is known as Vetiver, Vetivert, Khus or Khus-Khus. Its common names in other languages are Ilamichamver / Vettiver (Tamil), Ramacham (Malayalam), Vattiveeru (Kannada) Birina (Assamese) Khus-khus (Bengalee), Bala / Bena / Khus, Panni (Hindi). It has been used in our country since ancient times and is well known as a medicinal plant in the Ayurvedic science. It is interesting to know that the plant found a place in mythology. The well known epic Ramayana in the Hindu mythology refers to ramacham, bala etc. For several centuries Vetiver has been commercially cultivated for the scented oil that is distilled from its roots. In North India villagers weave these roots into mats, baskets, fans and ornaments. They also weave them into window coverings that freshen the air of village homes with a severe and penetrating scent. The roots and oil are known to repel insects. People in India and elsewhere have long used Vetiver roots among their clothes to keep insects away.

3. THE VETIVER GRASS TECHNOLOGY (VGT)

The Vetiver Grass Technology or Vetiver system (VS) as it is called now, in its most common form, is simply the establishment of a narrow (less than 1 meter wide) live grass barrier, in the form of a hedge, across the slope of the land. When applied correctly, the technology is effective on slopes from less than 1 to over 100%. A well established grass hedge will slow down rainfall run off, spreading it out evenly, and will trap runoff sediments to create natural terraces. Vertical intervals can be more accurately decided by observation. This is something the user can do; if rills start to develop below or above the hedge- another barrier can be planted to intercept them. The system is very user friendly. All this is possible with out the use of complex hydrological data and design, and without the aid of high cost consultants and surveyors. In China its use has extended from agriculture to engineering and mechanical devices are being replaced. It has been used successfully to stabilize flood embankments, river and canal embankments in many countries. In the early part of last century the sugar industry had recognized the value of Vetiver grass for conservation purpose and it was used in the West Indies and South Africa for this purpose. Although the sugar industry has used Vetiver grass as a vegetative soil conservation measure in isolated parts of the world for the past 50 years, it has gone unnoticed by researchers, even in the same countries. It has been overlooked by lecturers and professors teaching soil conservation. Strangely, it has never been a subject of any research till 1980s. Yet over 200 years, it has been used by farmers in India as a permanent hedge. It has been free of problems and dense enough to effectively filter silt out of runoff.

Around the world, as nations develop infrastructure to participate in the global economy, countries clear forests for agriculture, roads, railways, mines and reservoirs. As a result, billions of tons of soil are permanently lost each year with the consequential pollution and damage of downstream reservoirs. Research works carried out in this direction have resulted in development of some technologies that are useful in conserving soil and moisture. However, due to the high cost involved they remained out of reach of common man. As in medical treatment, despite researches and advances on the one hand, people are still resorting to benign results, often at lower costs. This, in fact, is a return to nature approach: as for certain problems, nature has already clues or answers to them. Bioengineering and phytoremediation are some of the cases in point.

Bioengineering or strictly speaking soil bioengineering is relatively a new branch of civil engineering. It attempts to use live materials, mainly vegetation, on its own or in integration with civil engineering works to address the problems of erosion and slope stabilisation. In late1980s and the following decade, due to heightened awareness of environmental issues and availability of knowledge and parameters of plants that can aid as well as lend credence to the designs, bioengineering became better known and accepted.

Phytoremediation refers to a green technology that uses plants to decontaminate polluted soils and water. It has gained popularity by leaps and bounds during the last few years because of the rediscovery of the vast potential of plants to do very effective jobs at such low costs compared to the ‘conventional’ clean up solutions, using mechanical or chemical means.

4. VETIVER SYSTEM IN TEA PLANTATIONS

The problem of soil erosion in Tea plantations in South India and North East India is getting worse over the years. Considerable expenditure is being incurred by estates in these regions due to works on water management and soil erosion. Although specimens of Vetiver grass and its sporadic use could be seen in some tea gardens its commercial use as soil and moisture conservation grass is yet to be fully recognized. It is of great interest to note that the first ever record on use of Vetiver for soil conservation along with some other gasses was documented by Eden in his well known publication entitled “TEA”. In his book reference regarding superiority of Vetiver over other grasses was made. (Eden, 1958). The tea growing regions in south India being hilly slopes, problems related to soil erosion is common due to heavy rainfall. Another problem in tea cultivation is the occurrence of drought due to shortfall of rain during the summer season. Soil and moisture conservation goes a long way in increasing tea productivity. Apart from the above, considerable expenditure is being incurred by estates in these regions due to works on water management and soil erosion.

As early as 1980, World Bank introduced vetiver grass for soil and water conservation in the agricultural sector (Grimshaw, 1995). During 1990s Vetiver was introduced in tea plantation of Tata Tea in south India for preventing soil erosion by the R&D Department of the Company (Haridas, 2002). Under this programme various aspects of use of vetiver system were experimented. The progress made on VS in tea plantations are given below.

5. IDENTIFICATION OF SUITABLE CULTIVAR

Different cultivars of vetiver collected from three different locations were evaluated for their suitability for use in the hill tracts of Munnar. The trial plots were established in the R&D Department at an altitude of 1200 m above MSL. The cultivars tested include ‘Madupatty’ (introduced to Munnar by the first author) and ‘Silentvalley’ (cultivars collected from a worker’s gardens of Madupatty Estate, Munnar, Kerala), ‘Pannimade’ and ‘Uralikal’ (cultivars collected from the worker’s gardens of Panimade and Uralikal Tea Estates, Valparai, Coimbatore District, Tamil Nadu) and ODV-1 to ODV-23 (cultivars collected from experimental plots of Aromatic and Medicinal Plant research station, Odakkali of Kerala Agricultural University, Kerala). The observation made on various biometric parameters and oil content on different cultivars is given in following table.

ariety	Length of roots (cm)	Total biomass (g)	Shoot weight (g)	Root weight (g)	Shoot : root ratio	No. of tillers	DMC %	Oil %
SVLY	75	5257	4647	610	7.62	115	81.16	1.07
PANN	92	7093	6513	580	11.23	155	86.43	0.27
MADU	73	507	303	203	1.49	28	83.50	0.30
ODV-1	81	3150	2933	217	13.52	108	85.20	0.84
ODV-2	68	1393	1153	240	4.80	96	85.31	0.70
ODV-3	83	1910	1653	257	6.43	72	76.00	0.42
ODV-4	77	2530	2217	313	7.08	122	76.36	0.41
ODV-5	72	2443	2040	403.3	5.06	89	85.00	0.55
ODV-6	66	670	463	206.7	2.24	31	86.79	0.68
ODV-7	96	4180	3710	470	7.89	115	80.23	0.81
ODV-8	91	1470	1243	227	5.48	44	85.89	0.37
ODV-9	91	5820	5277	543.0	9.72	209.0	91.64	0.33
ODV-10	78	987	743	243.3	3.05	34.0	85.21	-
ODV-11	93	4487	4110	377.0	10.90	147.0	88.60	0.64
ODV-12	78	2207	1920	287	6.69	53	90.17	0.31
ODV-13	47	227	127	100	1.27	10	89.69	0.58
ODV-14	89	1820	1517	303	5.01	56	86.15	0.18
ODV-15	87	1370	1080	290	3.72	70	90.30	0.30
ODV-16	90	2610	2280	330	6.91	103	89.93	0.46
ODV-17	85	1653	1397	256.7	5.44	65.3	91.50	0.29
ODV-18	89	1143	860	283.3	3.04	64	88.70	0.58
ODV-19	88	2267	1927	340	5.67	141	88.90	0.62
ODV-20	78	1758	1593	163	9.77	65	88.90	0.30
ODV-21	89	373	267	107	2.50	18	88.00	0.23
ODV-22	69	1367	1147	220	5.21	49	88.30	0.67
ODV-23	98	4367	3917	450	8.70	133	90.10	0.68
ODV-24	105	4173	3757	417	9.01	159	88.90	0.63
Average	**83**	**2490**	**2178**	**312**	**6.28**	**87**	**87**	**0.51**
SD	12.129	1769.555	1650.040	132.656	3.135	49.777	4.131	0.221

None of the cultivars used in the trials produced viable seeds. Observations indicated that cultivar 'Maduaptty" was suitable for hilly tracts where elevations ranged from 750 to 1 500m. This cultivar was found to be with less oil content in the roots unlike other ecotypes tried and hence will not attract people who are interested in the roots for oil. This feature was treated as a added advantage for obvious reasons studies indicated that the type "Pannimade" was tolerant to light shade under Anamallais conditions. The cultivar ODV-3 was found to be vigorous grower. It started to gain impressive grounds in other fields during the mid 1990s arising from some breakthrough researches that reveal the unique properties of this grass, which lends itself ideally for bioengineering and phytoremediation purposes. It is believed that as more information and records of its successful applications come to light, it may become not only an option but rather the option for bioengineering and phytoremediation measures in the New Millennium (Chomchalow, 2000).

6. METHOD OF PROPAGATION

Vetiver in cultivation rarely produces seeds. In vetiver literature, several terms have been used, sometime indiscriminately, to designate the parts of the vetiver plant that can be used in propagation.

- *Tiller* : (1) A shoot growing from the base of the stem of a plant ; (2) A shoot, especially one that sprouts from the base of a grass : (3) A shoot sprouts from the base of the stem of a vetiver plant. Tiller is the most popular part of the vetiver plant used in propagation since it is available in large quantity, employs simple technique, and gives good result.
- *Slip*: (1) A stem, root, twig, etc cut or broken of a plant and used for planting or grafting; cutting; scion; (2) A part of a plant cut or broken off for planting; a cutting; (3) A shoot cut off from a vetiver clump used for planting. Many people use this term synonymously with tiller. Some even erroneously call it a 'root division' (in Vetiver, the structure from which the slip grows is the base of the stem, not the root. The term 'tiller' is more appropriate to describe the planting material.

- *Culm*: (1) A stalk, stem; the jointed stem of various grasses, usually hollow; (2) The stem of the grass; (3) The above-ground part of the stem of a *vetiver plant.* The culm of the vetiver grass is strong, hard, and lignified, having prominent nodes with lateral buds that can form roots and shoots upon exposure to moist condition. Laying the cut pieces of culms on moist sand, or better under mist spray, results in the rapid formation of roots and shoots at each node.

- *Cutting*: (1) A slip or shoot cut away from a plant for rooting or grafitng; (2) A part of stem removed from a plant to propagate new plants, as through rooting; (3) Vetiver culm cut into sections with at least one node each used to propagate new plant. Although commonly used as propagating material in horticultural crops, cutting' is rarely used in vetiver. This term is probably synonymous with cut culm or culm-cutting.

- *Clump*: (1) A cluster, as of shrubs or trees; (2) A thick grouping, as of trees or bushes; (3) A cluster of tillers developed originally from a mother plant of the vetiver in all directions. In vetiver, a clump is formed when a plant has been grown for a certain period and produces numerous tillers in all directions.

7. METHOD OF PLANTING IN THE FIELD

While preparing the planting material the tillers are usually separated from the main clump. Dig out the clumps of Vetiver cutting the roots off about 10 cm below surface. Cut off the leaves about 25-30 cm. above the root and break the clumps into planting pieces or tillers taking care to discard dead tillers. Prepare the multiplication plot well by cultivating and getting rid of weeds. The area need not be leveled, as Vetiver tillers are extremely hardy. There should be moisture in the soil while planting the tillers. The tillers @ three tillers per pit are spaced at 40 cm apart. This wide spacing in multiplication plot/nursery gives each plant ample room to tiller or produce more planting material. In the first two months when the plants are getting established weed the area to keep the weeds under control. Once the plants start to grow vigorously, cut the leaf to about 50 cm. Cutting encourages "tillering" and produces more planting material in a short period. Plants grow faster and produce more tillers if fertilizer is applied. A mixture of 1:1 NP may be used to give 40 kg NP/ha. Always plant Vetiver in the wet season to ensure that they get full benefit of rain. A spacing of 15-20 cm should be given in order to form a hedge in areas where it is desired. Only a single row of tillers, three per pit, need to be planted. Once the hedges are established the only care needed is trimming to a height of about 30cm.

8. OTHER APPLICATIONS

8.1 Beach Protection

The beach in front of the resort near Chennai (Tamil Nadu) has been eroding into the sea. In order to prevent erosion, experimental planting of Vetiver (ecotype - Madupatty) was undertaken in July 2006. Three rows of Vetiver were planted at a spacing of 22 cm between the plants in the row and 1 m between the rows. The total area covered was 4 kms. The hedges were well established by end October. It was also found necessary to trim the plants once in two months because of vigorous growth. It was proved that Vetiver could be grown successfully to prevent sea erosion in coastal areas.

8.2 Environmental Protection

Paul Truong of Queensland, Australia was intrigued by the ability of this grass to thrive over a wide range of conditions, particularly in soils of high acidity as well as high alkalinity. Starting from some rather simple experiments on Vetiver and pH, he went on to test Vetiver's tolerance to a range of heavy metals (Truong and Baker, 1998). They showed that Vetiver possessed high tolerance to heavy metals. This finding led to his and others (Xia and Shu, 2003) initiatives in using Vetiver for dealing with polluted landscapes and sites, such as municipal land fills, mine tailings, acid sulphate soils, etc. Experiments and demonstrations have been carried out in Australia (Bevan and Truong, 2002), China (Zhang and Xia, 2003) and Thailand (Srisatit *et al*., 2003) to test Vetiver under extreme conditions, all with positive results. By the end of the century it was becoming clear that Vetiver grass had unique qualities that could be put to use in tackling not only land stability issues, but also water quality enhancement. Apart from farmland conservation the grass is used in the following areas.

8.3 Gully Rehabilitation

Together with physical measures the grass is widely applied to control the gully sides and heads.

8.4 Waterways Stabilisation

The walls of irrigation canals that have low angle of repose are better protected by planting Vetiver along both sides of the canals. In the same way river banks that have undercut/scouring effect were protected by planting Vetiver clumps without splitting into tillers.

8.5 Dam Catchment Area Protection

It is only the grass family that has proven to be effective in controlling the sediment from silting the dam. Elsewhere today, domestic water supply and hydroelectric authority involved in dam construction are convinced to use the grass to treat the catchments before any dam is built. Good examples and experiences are the dam built by one NGO called the Amahara Relief and Development Organization in the Northern part of Ethopia and the Fincha Hydro electric power plant in the South that used Vetiver to treat the whole catchments.

8.6 Rainwater Harvesting

Vetiver grass is useful in rainwater harvesting. Harvesting of rainwater through impounding it where it falls by means of ponds, check dams and in-large sized tanks is a well understood technique practiced for at least the last 1000 years. Over a period of time the tanks were neglected and as a result they were filled with silt and incapable of harvesting water to any significant extent. After desilting and deepening the lakes Vetiver may be planted around the lakes for stabilising the soil and recharging water.

8.7 Groundwater Recharging

Drought conditions will continue and are likely to worsen, if timely action is not taken at conserving water and harnessing rainwater. If recurring drought conditions have to be prevented, the only course open is rainwater harvesting practised on a regional scale by arresting the rapid run-off of water, allowing it to seep downward and augment the groundwater reservoir. It is this process of maintaining the ground water source and making it available throughout the year, which is termed as ground water recharge. Planting of Vetiver along the spring, rivulets and streams, provided shaded areas do not become a limiting factor for good growth of Vetiver is suggested.

8.8 Prevention of Entry of Weeds into the Field

Vetiver grass grows so densely that it can block the spread of other grasses including some of the world’s worst creeping grasses. In Zimbabwe tobacco farmers reportedly plant Vetiver around their fields to prevent invasion of other tough grasses. In Mauritius sugar cane growers rely on Vetiver to prevent Bermuda grass from penetrating their fields from adjacent roadsides. In High Range, for example, a Vetiver plot established at Kundaly in early 1990s kept Kikuyu grass (*Pennisetum clandestinum*) from creeping in. Obviously establishing Vetiver hedge along the periphery of tea fields could prevent invasion of deep rooted tough grass weeds.

8.9 Soil Microorganisms Associated with Vetiver

In many tropical countries Vetiver can grow and survive without nitrogen and phosphorous fertilizer application especially in the infertile soil. What or where is the nutrient source for Vetiver growth and development? It is documented that the soil microorganisms associated with Vetiver roots are nitrogen-fixing bacteria, phosphate-solubilizing microbes, mycorrhizal fungi and cellulolytic microorganisms.

Sunanthapongsuk *et al*. (2000) reported the study on soil microbial diversity in the rhizosphere of Vetiver grass. The results revealed the total soil microorganisms and cellulolytic microbes were in the range of 016 to 108 cells/g of dry soil. The amount of non-symbiotic nitrogen-fixing bacteria and phosphate-solubilizing microorganisms appeared in the areas of rhizosphere of the Vetiver root. Soil pH and organic matter percentages affected soil microbial population.

Sirpin *et al.* (2000) concluded that 35 isolates of N_2 fixing bacteria could be screened from the Vetiver root. Each strain had different potential in N_2 fixing ability and had difference in physiology and morphology of the colonies and the cells. N_2 fixing bacterial inoculation increased Vetiver growth and development particularly by increasing lateral root number, root dry weight, number of tillers, plant height, branch root number, root dry weight, culm dry weight and total plant dry weight. N_2 fixing bacteria produced plant growth regulators which are similar to IAA, IBA and GA and affected lateral root number and total biomass. The inoculated Vetiver with mixed strains of N_2- fixing bacteria showed the highest N_2-fixing ability; 30 to 40% of N^2 in Vetiver plant were derived from the atmosphere by using ^{15}N isotope dilution method for measurement of N_2-fixing ability.

9. CONCLUSION

Vetiver could be used for preventing soil erosion and conserving soil moisture in tea fields. Vetiver has made significant inroads in the minds of professionals around the world who several years back scoffed at the idea that a grass with a Tamil name and indigenous to India could be used to replace mechanical engineering works, could have multiple environmental applications and could offer inexpensive and reliable solutions to soil degradation, loss of soil fertility, ground water recharging, water quality enhancement and site rehabilitation in relation to industry and intensive commercial agriculture.

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