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Assessment of Yellow Sorghum Palem Pacha Jonna-1 (PYPS 2) Performance through on Farm Testing in Telangana

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ABSTRACT: In Southern Telangana zone, local yellow sorghums are very popular among the farming community as the soils of this area are light, annual rainfall between 350-450 mm, 80% of the cultivation is under rainfed and farmers highly preferred to take yellow jowar roti and millets products daily in their meal but the cultivated local yellow sorghums are very low yielder, prone to pest and diseases and having low protein content in grains. To address these challenges, Regional Agricultural Research Station, Palem developed Palem Pacha Jonna 1 (PYPS 2) which is dual purpose and high yielder, tolerance to pests and diseases and having high protein content (12.02%). On-farm trials were conducted by RARS, Palem, PJTSAU under the NICRA project from *kharif* 2015 to 2018 to evaluate the potential of the yellow sorghum cultivar PYPS 2 with proven production technologies in different districts with various farming situations of Telangana. The average higher grain yield was recorded in improved practice (1930.9 kg/ha) with a percent increase of 16.2% against farmers' practice (1663.1kg/ha). High dry fodder yield, height (287.6 cm), higher 100 seed weight (2.9 g/100 seed) were observed in improved practice as compared to farmers' practice with low dry fodder yield 4647.8 kg/ha, days to 50% flowering (66.6 days), plant height (263.6 cm) and 100 seed weight (2.6 g/100 seed) during *kharif* 2015- 2018. The extension gap, technology gap and technology index were recorded 267.8 kg/ha, 1069.1 kg/ha and 35.6%, respectively during the study period. The mean higher net returns were recorded in improved practice of Rs.60,966.9/ha than the farmers' practice Rs. 43,120.3/ha. The average benefit-cost ratio of 3.4 was noticed in improved practice against farmers' practice of 2.6. The mean of sustainability yield index and sustainability value index of improved practice were 0.77 and 0.69 than the farmers' practice 0.74 and 0.61 respectively, during the evaluation period.

Keywords: Sorghum, On-farm trials, Yield, Yield attributes, Economic returns, SYI, SVI.

INTRODUCTION

Millets are small seeded crops from the grass family that are hardy in arid and semi-arid ecosystem and are rain-fed crops that grow on marginal soils with low soil fertility and low moisture (Kimber *et al*., 2013). They require only 350 mm of water for growth and are resistant to high temperatures and drought-prone areas. Sorghum, bajra, finger millet, foxtail millet, little millet, barnyard millet and proso millet are important millets. Among these, sorghum (*Sorghum bicolor* L.) and pearl millet (*Pennisetum glaucum*) occupied more than 90% area than the other millets. These are traditional crops and used as a staple food and have high nutritional value and health advantages than other cereals that's why called as "nutricereals". In India, sorghum grown in an area of 4.35 mha with production of 4.63 MT with average productivity of 1064.0 kg/ha. In Telangana, 78,000 ha area occupied by sorghum with 120 lakh tonnes production and 1296.0 kg/ha average productivity (Anonymous, 2022).

Sorghum is grown both in the *kharif* and *rabi* seasons. In the *kharif* (rainy) season, it is grown as a rain-fed crop and in the *rabi* (post-rainy) it is grown with minimal irrigation and limited soil moisture. The rainy season produce is used for industrial and poultry purposes, whereas those from the post-rainy season are totally used for human consumption. The fodder from both seasons used as animal feed. Sorghum is mainly cultivated by resource poor, small and marginal farmers in semi-arid regions of the country (Rao *et al*., 2010). The area under grain sorghum has decreased from 18.61mha to 4.5mha from 1969-70 to 2021-22 due to new irrigation facilities, diversion of cultivation from millets to rice, maize, cotton, groundnut, and other high value cash crops. However, significant achievements made in research and development thereby productivity has been increased over the time from 522 kg/ha to 1064 kg/ha.

In farmers field, the productivity of the sorghum is low compared to the potential yield, and this is caused by the cultivation of old varieties, lack of knowledge about the availability of improved varieties and poor management practices (farmers' failure to adopt of recommended package of practices) (Ashoka *et al*., 2020). Reducing gap between the farmer's yield and demonstration yield is bridged by adopting the improved agronomic practices. The yield potential of the improved sorghum technologies developed from the research stations is far below of the average national productivity. The objective of the frontline demonstrations is to assess performance newly released cultivars and technologies in the farmer's field. The Government of India started frontline demonstrations in 2011 to include the scientists (who actually developed the technologies) in demonstrations and the goal was to increase awareness of the latest improved technologies, building farmer confidence, and refine the research programme. Front-line demonstrations are play major role for dissemination of agricultural technology among farmers and achieving the best yields possible with an improved package of practises (Kubsad and Kambrekar 2016; Srinivas *et al*., 2014).

Now a days, the farmers choice in a cultivar is dual purpose (both grain and fodder) and preferences differ from location to location. Keeping in view of these, On-farm trials were organized at different locations of the Telangana state with coordination of KVK's and DAATTC with improved yellow sorghum cultivar PYPS-2 with high protein, early duration (105 days), tolerance to grain mold, shoot fly and stem borer, taller plant height (280-310 cm), juicy type stem with compact panicle, tolerant to prolonged dry spells, tolerant to lodging, high protein content (12.02%) and potential yield (3000 kg/ha).

MATERIALS AND METHODS

On-farm trials were carried out for assessment of yellow sorghum cultivar PYPS-2 by RARS, Palem in different districts of Southern Telangana Zone with various farming situations of during *kharif* 2015(60), 2016(4), 2017(51) and in 2018(34) a part of the NICRA project. A total of 179 on-farm trials were organized in 40 villages of various districts of Telangana *i.e.*, Mahabubnagar, Nagarkurnool, Wanaparthy, Naranyanpet, Nalgonda, Mahabubabad and Ranga Reddy districts with an objective of promotion of improved yellow sorghum cultivar PYPS-2 with improved package of practice (Table 1). The scientists of RARS, Palem along with KVK and DAATTCs conducted baseline survey and collected data on farming practices in each village. Farmers were identified based on the survey, group discussions, interaction meetings, awareness programme and field visits and list of farmers who were interested in participating in on-farm trials was prepared with the coordination of KVK and DAATTC scientific staff.

Before conducting the farm demonstrations, scientists briefed benefits of improved varieties and latest package of practices pertaining to sorghum and also discussed about the problems associated with cultivation and the package of practices. Soil samples were collected (1 from each at a depth of one metre during visit) from selected farmers. Each demonstration was conducted in a 0.4 ha area, while the nearby field was considered as farmer's practice. The details of demonstrations and farmers practice were prescribed in Table 2. The scientists of RARS, Palem organized extension activities like farmer-scientist interactions, training programmes, method demonstrations, regular field visits for observation of pests and disease incidence, awareness programme was organized prior to crop harvest to highlight the advantages of improved technology over the existing practice and to spread awareness of it among local farmers or nearby villages.

Data growth, yield attributes and yield (grain and fodder), percent increase or decrease of yield, gross returns, net returns, benefit-cost ratio and technology gap, extension gap and technology index were recorded for both on-farm trials and farmers practice and compared both using the standard formula (Sawardekar *et al*., 2003).

$$\text{Impact yield (\%)} = \frac{\text{Yield of demonstration plot (kg/ha)} - \text{Yield of farmers practice (kg/ha)}}{\text{Yield of farmers practice (kg/ha)}} \times 100$$

Extension gap = Demonstrations yield (kg/ha)-Farmers practice (kg/ha)

Technology gap = Potential yield (kg/ha)-Demonstration yield (kg/ha)

$$\text{Technology index (\%)} = \frac{\text{Potential yield (kg/ha)} - \text{Demonstration yield (kg/ha)}}{\text{Potential yield (kg/ha)}} \times 100$$

Independent two sample t-test was used to analysed data, and the standard deviation was computed.

Sustainability indices were calculated by (Sustainability yield index and sustainability value index) using following formula

$$\text{SYI/SVI} = \frac{Y - O}{Y_{max}}$$

Y= estimated average yield/net returns

O= Standard deviation

Y_{max}= Maximum yield/Maximum net returns

RESULTS AND DISCUSSION

Yield and yield attributes. Results from On-farm demonstrations during *kharif* 2015 to 2018 showed that yellow sorghum variety Palem Pacha Jonna 1 (PYPS-2) had a significant mean higher grain yield of 1930.9 kg/ha with a percent increase of 16.2% over the farmer's practice of 1663.1 kg/ha (t-value 17.3; $P<0.00001$). The highest average grain yield was recorded during *kharif* 2018 with 1937.1 kg/ha, while lowest grain yield in *kharif* 2016 with 1925.4 kg/ha. The local checks exhibited the highest grain yield of 1671.0 kg/ha in 2017, whereas the lowest grain yield of 1656.1 kg/ha during *kharif* 2015 (Table 3). The improved variety of PYPS-2 gave significant average dry fodder yield of 5337.1 kg/ha as compared to local cultivar 4647.8 kg/ha. During the four years of demonstrations, the dry fodder yield of improved technology ranged from 5194.1 kg/ha to 5476.1 kg/ha, where as the local check varied from 4371.2 kg/ha to 5041.1 kg/ha. The improved yellow sorghum variety PYPS-2 showed shorter days to 50% flowering (60.5 days), taller plant height (287.6 cm) and more seed weight (2.9 g/100 seed) than the local check 66.6 days, 263.6 cm and 2.7 g/100 seed, respectively during the assessment period (Table 4).

In improved practice grain yield, dry fodder, yield attributes *i.e.*, days to 50% flowering, plant height and 100 seed weight were higher over the local practice it might be due to adoption of improved new sorghum variety PYPS-2 and also due to good management practices like seed treatment with imidacloprid @ 7ml/kg seed, recommended dosage of fertilizers, pre-emergence spray of atrazine herbicide @ 1.5kg/ha within 48 hrs of sowing, foliar spray of 19:19:19 @5g/L at prolonged dry spell, cypermethrin spray @0.25 ml/L at 15 days and 30 days after emergence for management of shoot fly, carbofuran granules 3G application @ 7.5kg/ha for stem borer control, preventive spray with propiconazole @ 1ml/L for grain mold control. In farmer's practice use of local variety, imbalance fertilizers application and non-adoption of control measures towards for pest and disease management. Similar findings were reported by Srinivas *et al*. (2014); Pritam *et al*. (2020) found that frontline demonstrations gain more yield compared to farmers' practice during the *kharif* season. Ashoka *et al*. (2020) observed that production of sorghum yield was significantly higher in frontline demonstrations than the farmers' practice.

Table 1: The details of number of mandals and villages covered under different districts of Telangana during *kharif* from 2015 to 2018.

District	Name of mandal	No. of villages (2015)	No. of villages (2016)	No. of villages (2017)	No of villages (2018)	Total villages
Mahabunagar	Addakal	1				1
	Balmoor	3				3
	Bhoothpur	1				1
	Bijinaepally	20				20
	Damargidda	1				1
	Ghanpur	4				4
	Gopalpet	1				1
	Hanwada	2	17	3		22
	Jadcherla	2		4		6
	Kalwakurthy	3				3
	Koilkonda	1				1
	Kosigi	1				1
	Mahabubnagar	7		2		9
	Midjil	1				1
	Nagarkurnool	1				1
	Nawabpet	3		1		4
	Tadoor	1				1
	Telkapally	2				2
	Thimmajipet	4				4
	Waddaepally	1				1
Nagarkurnool	Achampet			1		1
	Avancha			1		1
	Balmoor			2		2
	Bijinaepally			10		10
	Kalwakurthy			4		4
	Lingala			1		1
	Midjil			2		2
	Nagarkurnool			3		3
	Tadoor			1		1
	Vangoor			1		1
Wanaparthy	Gopalpet			1		1
	Wanaparthy			5		5
Naryanapet	Maddur		17	4		21
	Kosigi					0
	Marikal					0
	Narayanpet			1		1
Rangareddy	Yacharam			1	34	35
Nalgonda				1		1
Adilabad				1		1
Mahabubabad				1		1
Total		**60**	**34**	**51**	**34**	**179**

Table 2: Details of improved practice and farmers' practice in sorghum On-farm trials.

Particulars	Demonstration field	Farmers practice
Variety	PYPS 2	Local yellow sorghum
Seed rate and spacing	10 kg/ha Row to Row 45 × 12-15 cm (Plant to Plant) Remove excess plants at 15-20 days age of the crop	20 kg/ha & Spacing not maintained
Date of sowing	June first week to third week	May last week to June first week
Method of sowing	Line sowing	Broad casting and line sowing uneven plant population
Soil type	Red chalka soils	Red chalka soils
Irrigated (method of irrigation)	At critical stages when dry spell occurs give protective Irrigation during flowering and grain filling stages for better yields	Rainfed
Soil test	Done	Not follow
Seed treatment	Seed treatment with Imidacloprid 7.0 ml/kg seed.	Seed treatment was not done
Manures & fertilizers applied	FYM -10 t/ha As per the soil test recommendation 24N + 12P + 8K kg/acre which is equivalent to 50 kg DAP, 22.0 kg Urea and 30 kg MoP as Basal 45 kg Urea at 35-40 DAS	Imbalance and irregular fertilizers application and K_2O application
Weed management	Two manual weedings along with two intercultural operations with danti are effective. Pre emergence application of Atrazine @ 3 g/litre within 48 hrs of sowing coupled with one manual weeding at 35 days after sowing and one intercultural operation is also economical.	Manual weeding
Foliar spray of nutrients	19:19:19 @5g /l at the time of prolonged dry spell	No
Incidence of pests and disease	Spraying of cypermethrin @ 2.5 ml/l for management of shootfly at the time of 15 days after emergence. In heavy infested areas, soil application of carbofuran 3G at 8.0 kg/acre in seed furrows. Whorl application of Carbofuran 3G @ 3.0 kg/Acre at 30-35 days after emergence for control of spotted stem borer. Prophylatic spraying with propiconazole @ 1.0 ml/lfor management of grain mold.	Indiscriminate use of insecticides and fungicides
Harvesting	When the seed attain physiological maturity (black dot under seed), moisture content of 12-15% harvesting	20-25% moisture content

Table 3: Grain yield of sorghum under on farm trials during *kharif* 2015 to 2018.

Year	Number of demos	Yield (kg/ha)		% increase yield over the check
		IP	FP	
2015	60	1929.8	1656.1	16.5
2016	34	1925.4	1666.0	15.6
2017	51	1931.2	1671.0	15.6
2018	34	1937.1	1659.3	17.0
Average	179	1930.9	1663.1	16.2
SD		4.8	6.6	
t-value		17.3		
P-value		<0.00001		

Adoption gap. Extension gap between demonstrated technology and farmers' practice varied from 259.4 kg/ha to 277.8 kg/ha with a mean of 267.8 kg/ha during evaluation period *kharif* 2015 to 2018 (Table 5). The extension gap may be due to adoption of improved technology in demonstrations which resulted more grain yield compared to farmers practice (Ashoka *et al*., 2020). It was emphasized that in order to reverse trend of a significant extension gap, farmers must be educated through a various extension methods to adopt better practices (Thakur and Suryabhushan 2016). Improved technologies are becoming more popular through FLDs. Similar findings were observed by Ashoka *et al*. (2020); Pritam *et al*. (2020) in sorghum.

Technological gap exists between potential yield and demonstration yield. It might be caused by variations in soil fertility status, weather conditions, and non-adoption of improved package of practice (Kubsad and Kambrekar 2016). The technology gap was higher than extension gap indicates that there is a scope to further exploit the potential yield of the crop. The technology gap in grain yield was ranged between 1062.9 kg/ha to 1074.6 kg/ha (Table 5). The average technology gap was 1069.1 kg/ha. Similar results reported by Kubsad and Kumbreakar (2016); Ashoka *et al*. (2020); Pritam *et al*. (2020).

Technology index refers to the adoption of technology in frontline demonstrations through recommended package of practice being followed by the farmers. Technology index shows the viability of advanced technologies in agriculture. The highest value of the technology index indicates a lower level of the technology viability. Technology index for grain yield ranged from 35.4% to 35.8 % with an average of 35.6% during the four years of study period (Table 5). These results clearly indicate that there is a wide gap between the development of new technology and farmer's adoption. Similar findings reported by Kubsad and Kambrekar (2016) in sorghum, Lokesh *et al.* (2022) in pearl millet.

Economics. It is crucial to thorough examine of economic viability of any enhanced practice or technology demonstrated on farmers' fields in order to evaluate the profitability of any existing technology. Economic returns are determined by the cost of producing on grain yield and the minimum support price for produce, and these may vary from year to year because to changes in the price of inputs and labour. The critical inputs such as seed, fertilizer, micronutrients, weedicides and need-based plant protection inputs were considered as essential inputs that were to be used for both on-farm demonstrations and farmer's practice. The results revealed that in demonstration plots noticed highest gross returns of Rs. 86,412.6/ha as compared to farmers practice Rs. 69,852.8/ha during *kharif* 2015-2018. The highest gross returns of Rs.92,980.2/ha was obtained during *kharif* 2018, it was lowest in 2015, (Rs. 79,123.2/ha). The average net returns of improved practice was Rs. 60,966.9/ha over the farmers practice (Rs. 43,120.3/ha). The higher net returns were recorded during *kharif* 2018 (Rs. 66,509.6) and lowest in 2015 (Rs. 40,675.4/ha) during the demonstration period. Benefit cost ratio was also computed during the experimental period. The average benefit cost ratio was found to be higher in demonstration plots (3.4) as against farmers' practice (2.6) (Table 6). From the results of economic returns clearly indicated that the adoption of an improved sorghum variety, seed treatment, timely sowing, and need based plant protection measures and recommended dosage of fertilizers were main reasons to get higher net returns and benefit-cost ratio in demonstration plots. Whereas in farmers practice indigenous varieties, no seed treatment, non-adoption of plant protection measures and lack of application of fertilizers were the reasons for poor yields, low net returns and a poor benefit-cost ratio. These similar results conformity with Ashoka *et al.* (2020); Kubsad and Kambrekar (2016); Raju *et al*. (2022) in sorghum, Sharma *et al*. (2016) in wheat. From this study, it was clearly shown that the potential improved production technologies enhance the sorghum production and economic gains under rainfed farming situations.

Sustainability. A qualitative measure to assess the sustainability of an agricultural practice is the Sustainability yield index/Sustainability value index (Singh *et al*., 1990). It means to improving productivity when manage land over the long term (Randhawa, 1994). If standard deviation is high, the SYI will be low, indicates an unsustainable management system. The lower value of the standard deviation (SD) and co efficient of variation (CV) imply the sustainability of the system. The SYI value which ranges from zero to unity is calculated by the yields attained over time in the fields of various farmers who have participated in demonstrations. The sustainability yield index (SYI) in improved practice varied from 0.76 to 0.79, whereas in farmer's practice, it ranged from 0.72 to 0.77 during *kharif* 2015 to 2018, respectively. The sustainability yield index average in improved practice was 0.77 as compared to farmers' practice 0.74 during the study period. The sustainability value index ranged between from 0.67 to 0.70, whereas farmers practice it was 0.56 to 0.66. The sustainability value index was higher in improved practice 0.69 over the farmers' practice 0.61 (Table 7). Due to variations in farmer yield, the sustainability yield index and sustainability value index changed. These results clearly showed that improved practice/technology was more environmentally-friendly and sustainable than local practice. The similar results were notice by Narolia *et al*. (2013) in mustard, Reager *et al*. (2022); Shankar *et al*. (2022) in groundnut.

Table 4: Yield attributes of sorghum under On-farm trials and farmers' practice during *kharif* 2015 to 2018.

Year	DFF (days)		Plant height (cm)		Dry fodder yield (kg/ha)		Seed weight (g)	
	IP	FP	IP	FP	IP	FP	IP	FP
2015	60.6	66.6	286.9	258.1	5194.1	4371.2	2.9	2.7
2016	59.8	66.6	284.8	260.8	5272.7	4548.6	3.0	2.7
2017	60.2	66.2	285.4	265.6	5476.1	5041.1	2.9	2.8
2018	61.5	67.1	293.2	269.8	5405.4	4630.4	2.7	2.5
Average	60.5	66.6	287.6	263.6	5337.1	4647.8	2.9	2.7
SD					127.2	283.6		
t-value	29.7		16.2		14.0		6.4	
P-value	< 0.00001		< 0.00001		<0.00001		<0.00001	

IP=improved practice; FP=Farmers' practice; SD= Standard deviation

Table 5: Performance of improved technology on pod yield, extension gap, technology gap and technology index in sorghum during *kharif* 2015 to 2018

Year	Potential yield (kg/ha)	Yield (kg/ha)		Extension gap (kg/ha)	Technology gap (kg/ha)	Technology index (%)
		IP	FP			
2015	3000	1929.8	1656.1	273.7	1070.2	35.7
2016	3000	1925.4	1666.0	259.4	1074.6	35.8
2017	3000	1931.2	1671.0	260.3	1068.8	35.6
2018	3000	1937.1	1659.3	277.8	1062.9	35.4
Average	3000	1930.9	1663.1	267.8	1069.1	35.6

IP=improved practice; FP=Farmers' practice

Table 6: Impact of improved technologies on economics of sorghum during *kharif* 2015 to 2018.

Year	Gross returns (Rs./ha)		Cost of cultivation (Rs./ha)		Net returns (Rs./ha)		B:C ratio	
	IP	FP	IP	FP	IP	FP	IP	FP
2015	79123.2	64587.9	23091.7	23912.5	56031.5	40675.4	3.4	2.7
2016	86642.2	69973.2	25735.3	27007.4	60906.9	42965.9	3.4	2.6
2017	86904.7	70180.4	26485.3	27892.2	60419.4	42288.2	3.3	2.5
2018	92980.2	74669.6	26470.6	28117.6	66509.6	46551.9	3.5	2.7
Average	86412.6	69852.8	25445.7	26732.4	60966.9	43120.3	3.4	2.6

IP=improved practice; FP=Farmers' practice

Table 7: Effect of production practices on Sustainability Yield Index (SYI) and Sustainability Value Index (SVI) in sorghum during *kharif* 2015 to 2018.

Particulars	2015		2016		2017		2018		Mean	
	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP
Max	2188.0	1942.0	2157.0	1942.0	2162.0	1956.0	2138.0	1884.0	2161.3	1931.0
Min	1635.0	1447.0	1664.0	1462.0	1642.0	1441.0	1646.0	1456.0	1646.8	1451.5
Av	1930.0	1656.0	1925.0	1666.0	1931.0	1670.0	1937.0	1659.0	1930.8	1662.8
SD	276.7	248.5	246.6	240.9	260.5	258.0	247.4	214.1	257.7	240.3
C.V. (%)	14.4	14.7	12.8	14.2	13.6	15.3	13.0	12.8	13.5	14.3
Net returns Max	67208.0	52238.0	71635.0	54064.0	70845.0	54652.0	77124.0	56280.0	71703.0	54308.5
Net returns Min	44535.0	32550.0	49355.0	34154.0	47890.0	31772.0	52488.0	37065.0	48567.0	33885.3
Net returns Av.	56031.5	40675.0	60907.0	42966.0	60420.0	42288.0	66510.0	46552.0	60967.1	43120.3
SD	11336.9	9894.0	11142.5	9976.8	11493.5	11452.4	12357.2	9607.6	11578.0	10227.0
C.V. (%)	20.2	23.6	18.3	22.8	19.2	26.6	18.9	20.6	19.1	23.3
SYI	0.76	0.72	0.78	0.73	0.77	0.72	0.79	0.77	0.77	0.74
SVI	0.67	0.59	0.69	0.61	0.69	0.56	0.70	0.66	0.69	0.61

IP=improved practice; FP=Farmers' practice; SD=Standard deviation; C.V.= Coefficient variation; SYI=Sustainability Yield Index; SVI=Sustainability Value Index.

CONCLUSIONS

The present study clearly indicated that, yellow sorghum variety having higher grain yield, dry fodder yield, less days to 50% flowering, taller plant height and more 100 seed weight than the farmers practice. The gross net returns and benefit cost ratio were also higher in improved practice over the farmers practice. The sustainability yield index /sustainability Value index were recorded maximum in improved practice. The study showed the potential of the Palem Pacha Jonna 1variety suitable for rainfed cultivation in India.

FUTURE SCOPE

Sorghum is such a amazing crop that provides food to the farmers, fodder to the animals, fuel to the industries and especially health to all the human beings and can cultivate with minimal resources within short period but come up with additional benefits to the farmers.

Front line demonstrations are powerful tools for extension personal to disseminate the efficiency of a good technology among the farming community hence it should be encouraged.

The scope for betterment of health using value added products of sorghum well as of our economy has opened up new vistas of business opportunity for commercial products with abundant nutrients.

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