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Participatory varietal and adoption behaviour evaluation for off-season tomato cultivation on rainfed sloping lands of southern Odisha

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ABSTRACT

A study under Front Line Demonstrations (FLDs) was conducted at Krishi Vigyan Kendra, Semiliguda from 2009-2014 to evaluate the performance of tomato varieties *Utkal Kumari, Utkal Raja, Utkal Pragya* and *Arvind*. Hybrid variety '*Arvind*' yielded 289 q ha^{-1} and amid open pollinated varieties *Utkal Kumari* registered mean yield 213 q ha^{-1}. The increase in fruit yield was to the tune of 47, 50, 42 and 51% for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively over Farmers' Practice (FP). Among different cultivars; lowest extension gap of 32 q ha^{-1} was obtained in *Utkal Pragya* whereas highest extension gap of 86 q ha^{-1} was for variety *Arvind*. The technology gap for tested varieties was 187, 211, 210 and 209 q ha^{-1} for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively. Net returns analysis shows that hybrid variety '*Arvind*' fetched maximum net returns of ₹ 2,59,363 and ₹ 1,70,488 under FLD and FP, respectively. For conservation measures, maximum adoption score was recorded for contour bunding (72.3) followed by ridge furrow cultivation (65.1). Water use efficiency (WUE) was 21.1, 22.7, 41.4 and 17.9% higher in demonstration plot than FP for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively. Matrix ranking incites that '*Arvind*' was the most preferred variety of tomato followed by *Utkal Kumari*.

1. INTRODUCTION

Tomato (*Solanum esculentum* L.) is a popular solanaceous vegetable crop cultivated throughout the world. It is rich in vitamin A, C, potassium, minerals, antioxidants and fibers (Kaloo, 1993). In India, it is grown in 0.90 m ha area with 17.8 mt production and 19 t ha^{-1} productivity. Odisha ranks third among Indian states with an area of 0.097 m ha and production of 1.38 mt (IHD, 2014). Koraput district of southern Odisha possess productivity of 15 t ha^{-1} from an area of 3376 ha. Tomato is largely grown as winter crop in the irrigated patches with perennial streams as source of irrigation. Owing to peak production in *rabi* (winter) season combined with poor storage facilities in this backward region, there is market surfeit which leads to fall in sale price coupled with substantial spoilage. In general, summer and rainy seasons are the lean periods for tomato production where demand remains high. The traditional tomato cultivars raised in off-season are poor performer in monsoon season due to problems of rotting and wilting due to heavy rains. As tomato crop is raised on sloping lands, resource conservation measures are needed to combine with best package of practices to use the rain-water efficiently and reaping good harvest.

FLDs on tomato crop's newly released early maturing, high yielding and disease resistant varieties *viz. Utkal Kumari, Utkal Raja, Utkal Pragya* (all open pollinated) and *Arvind* (hybrid) on farmers' field may be helpful, to boost tomato production specifically in off-season (South-west monsoon). The released varieties have resistance to leaf blight, fungal and bacterial wilt. These varieties yield up to 40 t ha^{-1} in 90 days after transplanting. These features are highly suitable for their cultivation as off-season crop under agro-ecology of southern Odisha. These factors intended KVK, Semiliguda to conduct FLDs on off-season

tomato in Koraput district of Odisha with the specific objectives, i) to evaluate the performance of high yielding tomato varieties under off-season rainfed conditions; and ii) to study the economics, extension and technology gaps for making appropriate agro-techniques *vis-à-vis* extension methodologies for higher adoption.

2. MATERIALS AND METHODS

Farmers' Selection

To evaluate tomato varieties in off-season cultivation, a number of FLDs were conducted in different villages of Koraput district. KVK conducted an investigation in which all the constraints in tomato production were identified through Participatory Rural Appraisal (PRA), farmer meetings and training programs. Field diagnostic visits and questionnaires were conducted. Thus based on the farmers' demand for a good variety for off-season, 120 FLDs were conducted in 8 villages of different blocks of Koraput district of Odisha under rainfed situations during 2009-14.

Demonstration Management and Monitoring

Each FLD was piloted in an area of 400-800 m^2 in *kharif* season (June-September) along with Farmers' Practice (FP) in same area. Demonstration package under FLDs with other comparative technological details with FP are given in Table 1. The FLDs were strictly monitored by the farm scientists of KVK, Semiliguda from nursery raising to fruit picking. Before execution of FLD, each year training programs were organized for the selected village farmers to impart the technological know-how on off-season tomato cultivation. All other steps like site selection, layout of demonstrations, farmers' participation *etc.* were followed as suggested by Choudhary (1999).

Data Collection and Statistical Analysis

The data was collected through survey method. The major tools used for data collection were exhaustive village survey, interview schedules (structured and semi-structured), in-depth discussion and secondary data sources. Taking into consideration the scope and objectives of the study, a well-structured interview schedule was prepared. Based on the result of pre-test, suitable modifications were made and a final interview schedule was prepared. The fruit yield of demonstrations as well as FP (local check) were recorded and analysed according to different parameters suggested by Verma *et al.* (2014). On the basis of prevailing market prices (*Utkal Kumari* (₹ 1,047 q^{-1}), *Utkal Raja* (₹ 1,047 q^{-1}), *Utkal Pragya* (₹ 1,212 q^{-1}) and *Arvind* (₹ 1,112 q^{-1}); income, technological and adoption gaps were calculated as given below:

1. Extension Gap = Demonstration yield - FP yield
2. Technology Gap = Potential yield - Demonstration yield
3. Technology Index = (Pi - Di)/ Pi x 100

Where, Pi = Potential yield of i^{th} crop; Di = Average demonstration yield of i^{th} crop.

4. Additional Return = Demonstration return -FP return
5. Effective Gain = Additional return (Ar) -Additional cost (Ac)
6. Increment B: C ratio = Ar/Ac

The rainfall data was collected from annual reports of ICAR-IISWC, Research Centre, Sunabeda (Anonymous, 2014). Effective rainfall was derived on the basis of seasonal rainfall using FAO CROPWAT software. During the survey work it was found that in farmers' field Soil Water Conservation (SWC) works have been carried out by various government agencies and line departments. These extension agencies are making the farmer cognizant about the ways and means of scientific resource conservation. Common conservation measures *viz.,* contour bunding, mulching and ridge furrow sowing were uniformly observed in selected farmers' fields. These three SWC measure adoptions were judged in farmers' field and adoption score was given. The adoption score was determined based on the weighted score assigned to different parameters following Bhairamkar *et al.* (2011) and matrix ranking by Biradar and Tomer (1999).

Table: 1
Demonstration package and farmers' practice under FLD's in off- season tomato cultivation

S.No.	Technology component	Demonstration plot	Farmer practice
1.	Variety	Open pollinated/hybrid	Local
2.	Seed rate	500 g ha^{-1} (open pollinated) 120 g ha^{-1} (hybrid)	700-800 g ha^{-1} (open pollinated) 300 g ha^{-1} (hybrid)
3.	Seed treatment	Bavistine @ 2 g kg^{-1} seed + Streptocycline @ 0.1g kg^{-1} seed	Nil
4.	Sowing method	Raised bed, line sowing	Flat sowing, Broadcasting
5.	Staking	Full	Nil
6.	Nursery management	Low tunnel / low hut	Open conditions
7.	Fertilizer dose (NPK kg ha^{-1})	Recommended (125:50:50)	Partial (<75: <30:0)
8.	Micronutrients	Boron @ 5 kg ha^{-1}, Lime 5 q ha^{-1}	Nil
9.	Weed control	Metribuzine @ 1.5 kg ha^{-1} + 1 hand weeding	2 Hand weedings
10.	Conservation measures	Contour ridge furrow planting, Mulching, Contour bunding	Small bunds
11.	Technical guidance	Time to time	Nil

3. RESULTS AND DISCUSSION

Rainfall Pattern and Crop Establishment

The total rainfall received during the off-season tomato cultivation demonstration is presented in Fig. 1. A cursory gaze to the rainfall pattern shows its erratic trend; particularly during September, 2009 and August, 2012 in which rainfall deviated below and above average *i.e.* 252 and 313 mm, respectively. On an average (2009-14), 9, 17, 18 and 12 rainy days aroused in June, July, August and September months, respectively. With the inception of monsoon season, heavy showers and strong winds harshly affect nursery in second fortnight of June. This affects the tomato yield with poor germination, seedling mortality which leads to poor plant stand. Hence, much care is required in raising the monsoon season nursery. Low tunnel technique for nursery raising (Thakur and Devi, 2013) was adopted for off-season tomato cultivation. Tomato seedlings were raised in protected moisturized conditions and 25 days old saplings were transplanted in the fields during last week of July to beginning of August every year. To avoid the rainfall splash on seed germination and its subsequent growth, the nursery was protected with straw mulch as low hut, as a result of which seedling mortality was controlled.

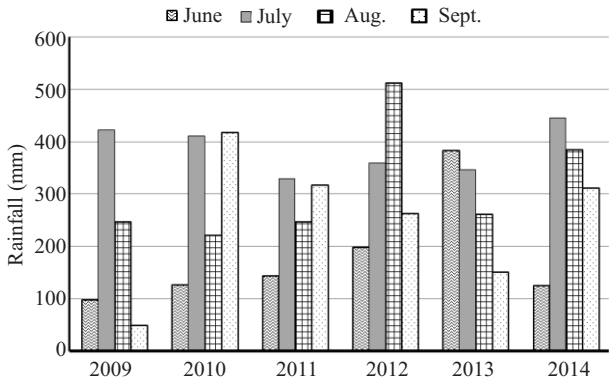

Fig. 1. Rainfall distribution during off-season cultivation

During the grand growth period (August and September), rainfall volume was sufficient to meet the irrigation demand; however, in 2009 a paltry, 297 mm rainfall was received which created stress in the standing crop. During mentioned months an average (2009-14) rainfall of 385 and 313 mm, respectively was sufficient to support the reproductive and fruiting stage of the crop. Staking of the tomato plants with sticks in last week of July protected the crop from fruit rotting during incessant rain. From this elucidation, it can be concluded that benefit from the early rainfall should be taken by raising seedlings in protected nursery to get maximum fruit yield.

Tomato Fruit Yield

A cursory gaze on Table 2 indicates higher fruit yield [average of 3 years *Utkal Kumari* (2009-11), *Utkal Raja* (2010-12), *Arvind* (2011-13), *Utkal Pragya* (2012-12)] of all the improved tomato cultivars higher in comparison to existing FP. The increase was to the tune of 21, 22, 42 and 18% for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively over FP. Further scrutiny of the data shows that in comparison to each variety's potential yield, only 50-55% yield was obtained. The reason attributed is that the varieties are raised in off-season (monsoon). Among different varieties, hybrid tomato '*Arvind*' recorded an impressive yield of 289 q ha^{-1}. In terms of fruit yield ha^{-1}. Which was double of the selected open pollinated varieties. Amid open pollinated varieties, *Utkal Kumari* registered maximum mean yield (213 q ha^{-1}). An average of 27% yield advantage was recorded under FLDs carried out with improved seed material, scientific technology package of conservation agriculture in comparison to FP. Similar findings are reported by Mohanty and Prusti (2001) and

Table: 2
Tomato yield, gap and economic analysis under front line demonstrations in farmers' fields (Mean of 3 years)

Variety	Yield (q ha^{-1})			Increase over FP (%)	Ext. gap (q ha^{-1})	Tech. gap (q ha^{-1})	Technology index (%)	Cost of cultivation (₹ ha^{-1})		Net Returns (₹ ha^{-1})		Add. cost (₹ ha^{-1})	Eff. gain (₹ ha^{-1})	IBCR
	PY	DP	FP					DP	FP	DP	FP			
Utkal Kumari	400	213	176	21	37	187	47	45,018	38,698	177,692	145,168	6,320	32,523	6.3
SD	-	3.06	1.15	-	3.46	3.06	-	166	790	15770	10029	624	6325	1.60
SE±	-	1.76	0.67	-	2.00	1.76	-	96	456	9105	5790	360	3652	0.93
Utkal Raja	420	209	171	22	38	211	50	57,299	51,343	161,366	127,378	5,956	33,988	6.7
SD	-	5.73	5.51	-	1.13	5.73	-	706	120	14797	13744	603	1154	0.60
SE±	-	3.31	3.18	-	0.65	3.31	-	408	69	8543	7935	348	666	0.35
Arvind	500	289	204	42	86	210	42	62,358	55,870	259,363	170,488	6,488	88,875	15.3
SD	-	4.04	2.25	-	6.29	4.04	-	2785	771	18674	11492	2031	9199	3.10
SE±	-	2.33	1.30	-	3.63	2.33	-	1608	445	10781	6635	1173	5311	1.79
Utkal Pragya	412	202	171	18	32	209	51	57,738	51,904	187,380	154,857	5,834	32,523	6.5
SD	-	1.95	0.76	-	2.72	1.95	-	1358	1144	26354	21354	556	5622	0.45
SE±	-	1.13	0.44	-	1.57	1.13	-	784	661	15215	12329	321	3246	0.26

DY - Demonstration Plot, FP - Farmers' practice, PY - Potential yield, IBCR - Incremental benefit cost ratio

Dass *et al.,* 2008. Sivaiah *et al.* (2013) in their trial deliberated on the importance of input responsive variety *Utkal Raja* which has enhanced photosynthetic efficiency and wilt tolerance characters. These characters lead to increased production and accumulation of carbohydrates with favorable effect on vegetative growth and fruit yield.

Gap Analysis

An extension gap ranging from 32-86 q ha^{-1} in yield was observed between FLD and FP throughout the years (Table 2). Among different cultivars, lowest extension gap of 32 q ha^{-1} was obtained in *Utkal Pragya* which owed to higher yield, whereas highest extension gap of 86 q ha^{-1} was in variety *Arvind* which points towards poor yields under FP due to various reasons. Overall such gaps are minimized with improved seed material, healthy seedling nursery, staking and adoption of improved production technology in the demonstrations Maharana *et al.* (2014).

Wide technology gaps were observed during the course of demonstrations. The average technology gap of total 120 FLD's for tested varieties was 187, 211, 210 and 209 q ha^{-1} for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively, which is 50% of variety's potential yield. This indicates that under field conditions only 50% of variety's potential yield is obtained. This may be attributed mainly to ill distribution of rainfall, variations in biotic and abiotic stresses observed across different plant growth stages. The study also showed a wide gap between the potential yields and demonstration yields which suggest further refinement in generated farm technology with location-specific crop management recommendations (Choudhary and Suri, 2014).

Technology index designates the potential, feasibility and repeatability in the performance of the evolved technology in farmers' fields. Lower the value of technology index, higher is the viability of the improved technology. Technology index spun around 40-50% during the years of FLDs. Technology index for all the demonstrations during different years was in accordance with technology gap. Higher value of technology index in *Utkal Raja* (50%) and *Utkal Pragya* (51) reflected insufficient extension services for variety's transfer to farmers' fields. Effort should be made with better extension to bridge this gap with better demonstration of technology in farmers' fields (Yadav *et al.,* 2014).

Economic Analysis

Economics of FLDs was assessed on the then market prices and all the variable costs were considered in calculating the cost of cultivation and the detailed economic returns are presented in Table 2. It indicates that owing to improved seed, treatment, fertilizers and other inputs, the cost of cultivation in demonstration plots was higher in comparison to FP. The cost of cultivation for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya* was ₹ 45,018, 57,299, 62,358 and 57,738 ha^{-1}, respectively. This was ₹ 6320, 5956, 6488 and 5834 ha^{-1} higher over FP. Net returns analysis shows that hybrid variety '*Arvind*' fetched maximum net returns of ₹ 2,59,363 and ₹ 1,70,488 under FLD and FP, respectively. In terms of fruit yield, best performer was *Utkal Kumari* (213 q ha^{-1}) followed by *Utkal Raja* (209 q ha^{-1}). But due to high market price for *Utkal Pragya* it fetched higher net returns to the tune of ₹ 1,87,380 ha^{-1}. The IBCR was maximum (15.3) for variety '*Arvind*' and among open pollinated varieties highest IBCR was of *Utkal Kumari* (6.7). It indicates that with small additional investments larger effective gains are obtained, hence IBCR value is high. It shows that higher market price during off-season makes improved variety cultivation a profitable venture. Enhanced fiscal returns in terms of gross, net and additional returns through improved farm technology have also been reported by Balai *et al.* (2013).

Resource Conservation

The farmers of Koraput region are practicing agriculture on slopping lands since time immemorial. Conservation of natural assets like soil and water are in their traditional knowledge (Adhikary *et al.,* 2015). Survey data on tomato cultivation on diverse sloping land is classified in Table 3. On SWC measures adoption score an average value of 62.5 (partial adoption) was obtained. A closer look to the values of adoption indicates adoption score of all the measures increased in progressive years. This shows change in farmer's attitude from awareness to full adoption. The mean maximum adoption values were highest for contour bunding (72.3) followed by ridge furrow cultivation (65.1). Mulching, an important practice in SWC under tomato cultivation engrossed petite score of 50.1. The reason attributed is the divergence of mulch material, crop residues for fodder and fuel wood.

Data on water use of different tomato cultivars for respective year is also presented in Table 3. On the basis of the crop duration in different years (2009-2014) the crop water use exhibited wide variation. Overall, WUE in demonstration plots was 20% higher than of FP over the years. On 3 years mean data basis WUE was 37.2, 32.4, 43.0 and 28.3 kg ha^{-1} mm in demonstration plot for *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya*, respectively which was 21.1, 22.7, 41.4 and 17.9% higher than FP. Higher values of WUE in demonstration plots are owing to better plant nutrition and higher moisture availability during crop duration. SWC measures neutralize the erratic rainfall effects and water stress period at critical crop growth stages with *in-situ* moisture conservation. From the data, it is evident that use of improved SWC practices has greatly enhanced the WUE of tomato crop in the demonstration plots over FP. Although the crop water use was the same under both the situations (Choudhary *et al.,* 2009).

Table: 3
Resource conservation adoption and water use efficiency in front line demonstrations

Variety	Year	Slope Range (%)	SWC measures adoption score*				Growth period (days)	Rainy Days	Consumptive water use (mm)	Water use efficiency (kg ha^{-1} mm)	
			RF sowing	Mulching	Contour bunding	Avg.				DP	FP
Utkal Kumari	2009	2-4	28	38	44	36.7	135	40	480	43.7	36.4
	2010		55	55	65	58.3	120	59	670	31.7	26.4
	2011		72	76	82	76.7	128	54	593	36.4	29.5
Utkal Raja	2010	3-5	45	24	55	41.3	129	55	681	31.0	25.1
	2011		68	45	82	65.0	125	52	585	34.7	28.2
	2012		82	50	86	72.7	139	51	681	31.4	25.8
Arvind	2011	1-2	60	45	65	56.7	132	49	605	47.9	33.7
	2012		78	68	85	77.0	130	54	681	41.8	30.2
	2013		95	72	88	85.0	128	48	744	39.4	27.2
Utkal Pragya	2012	1-3	50	25	55	43.3	132	57	675	29.6	25.5
	2013		68	38	82	62.7	135	54	750	27.2	22.7
	2014		80	65	89	78.0	137	43	719	28.2	23.8

*76-100- Full adoption, 51-75 - Partial adoption, 26-50- Knowledge, 0-25-Non adoption

Matrix Ranking

Matrix ranking is a PRA technique in which farmers follow their own criteria to rank a variety. Matrix analysis was conducted for 4 tomato varieties used in FLD to know the farmers' preferences and the results are displayed in Table 4. Results indicate that '*Arvind*' was the most preferred variety of tomato followed by *Utkal Kumari*. This could be ascribed to hybrid variety's higher yield potential, resistsance to wilting and leaf curl virus which are major problem in this high rainfall region. Another important aspect of tomato is shelf life for which '*Arvind*' received maximum score followed by *Utkal Pragya*. However, for the trait wilt tolerance, variety *Utkal Kumari* received maximum score. A perusal of listed traits signposts that farmers consider insect-pest and disease as the major problems for tomato cultivation during off-season. Overall, hybrid variety ranked first which was closely followed by *Utkal Kumari.* From this survey, the extension agency got an insight of the farmers' preference for selecting a variety. These traits are deciding factors in adoption of technology or scientific practice (Kersten, 2001).

Table: 4
Matrix preference ranking of tomato cultivars

S.No.	Priortization criteria	Tomato varitiey			
		Utkal Raja	*Utkal Kumari*	*Utkal Pragya*	*Arvind*
1.	Cost of seed	2	2	2	1
2.	Wilt tolerance	1	4	2	3
3.	Leaf Curl Virus	2	3	1	4
4.	Fruit borer attack	1	2	3	4
5.	Fruit size	2	4	1	3
6.	Fruit rotting	2	4	1	3
7.	Yield	2	3	1	4
8.	Shelf life	1	2	3	4
9.	Market demand	2	4	1	3
10.	Profit	3	2	1	4
	Total score	18	30	16	33
	Rank	III	II	IV	I

4. CONCLUSIONS

In a field demonstration in Koraput district of southern Odisha, improved tomato varieties *Utkal Kumari, Utkal Raja, Arvind* and *Utkal Pragya* with scientific production technologies led to an average increase of the fruit yield by 25.7% over existing FP. Among different varieties, best performance was '*Arvind'* followed by '*Utkal Raja'*. The increase in cost of cultivation under improved method was ₹ 5500-6500 ha^{-1} over FP given net returns to the tune of ₹ 2,50,000 ha^{-1}. This increase in cost of cultivation, progressive and marginal farmers can afford and can reap higher benefits. Adoption of SWC measures found place in farmers' fields under improved tomato cultivation. FLD program was also effective in changing attitude, skill and knowledge of Tomato growers towards adoption of conservation based improved practices. Extension agency contact with farmers should be reinforced for higher adoption of improved tomato production technologies by using SWC practices. Rural youth and young farmers should be given enough support by training and education so that they can adopt scientific cultivation for better livelihood prospects.

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