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Real Time Contingency Measures to Cope with Rainfall Variability in Southern Karnataka

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ABSTRACT: Real time contingency practices viz., selection of varieties, date of sowing, method of crop establishment, soil and moisture conservation practices were demonstrated in the Chikkamaranahalli cluster villages, Bengaluru rural district of Karnataka during 2011 to 2014. Selection of long duration variety (MR-1) for July sowing, medium duration (GPU-28) for August 1st fortnight and short duration (GPU-48) for August 2nd fort night performed better. *In-situ* conservation moisture through opening of conservation furrow between paired rows of pigeonpea under finger millet + pigeonpea (8:2) and groundnut + pigeonpea (8:2) recorded significantly higher yields (2749 kg/ha and 1347 kg/ha, respectively) compared to farmers' practice. Among different methods of establishment in finger millet, transplanting recorded significantly higher grain yield (2461 kg/ha) and sowing of finger millet using modified bullock drawn seed drill recorded significantly higher yield (2417 kg/ha) compared to conventional method of broadcasting.

Key word: Real time contingency, climate resilience, productivity, profitability, RWUE

Introduction

Rainfed agriculture occupies a prominent place in Indian economy and rural livelihoods. In India, agriculture is the source of livelihood for nearly two-thirds of the population. Of the 141 m ha of net sown area in the country, 80 m ha is rainfed and will remain so for at least for a foreseeable future (Srinivasarao *et al.*, 2013). The impact of climate change and variability in the country on agricultural production is quite evident in the recent years. Climate change threatens the sustainability of modern day agriculture. Constantly changing climatic conditions around the world demand constant efforts to understand and adapt to environmental challenges for sustainable crop production. Sustainable crop production requires plants that are more productive; use nutrients and water more efficiently, have greater resistance to insect pests and diseases, and are more tolerant to climatic extremities viz., drought, flood, frost and high temperature.

The weather aberrations like drought and floods, extreme events like high intense rainfall, frost, hail storm, heat wave, cold wave, etc. are recurrent in most parts of the country in the crop growing seasons. The South-West monsoon account for nearly 75% of the precipitation received in the country and exerts a strong influence on the *kharif* food grain production and the economy in terms of agricultural output, farmers' income and price stability. The onset of South-West monsoon, the amount of rainfall and its distribution are crucial factors which influence the performance of agriculture. The probability of erratic monsoon rains is about 40%, which implies that in 4 out of 10 years there would be an adverse impact on the crop production (Srinivasarao *et al.*, 2013). There is a need for developing appropriate strategies to deal with such eventualities. Many contingency plans are available at different scales. However, any contingency intervention either technology related (land, water, soil, crop) or institutional and policy based, which are implemented on a real time basis in any crop growing season considered as 'real time contingency plan' is the need of the hour to stabilize crop stands, production and income in rain-fed regions.

Finger millet is one of the important cereal grown on the *Alfisols* of Southern Karnataka. In Karnataka, finger millet is grown in an area of 7.64 lakh ha with a production of 11.96 lakh tones and the productivity is 1, -647 kg/ha. Rainfed finger millet alone contributes 95.74% of the total area with production of 11.30 lakh tones. The major area under finger millet is covered in Central (Zone 4), Eastern (Zone 5) and Southern (Zone 6) dry Zones of Karnataka. The other predominant crops in the domain area are sorghum, groundnut, castor, niger, sesame, sunflower, soybean, pigeonpea, cowpea, field bean, mungbean and horse gram. The rainfed area is dominated by resource poor small and marginal farmers. The predominant cropping system in the area is monocropping of finger millet and groundnut with *akkadi* (mixed crop) crops with indefinite row proportion during *Kharif* season.

Rainfall is the key variable influencing crop productivity in rainfed farming. Intermittent and prolonged droughts are a major cause of yield reduction in most crops. Based on the farmer's need, technical interventions were taken up under NICRA (National Innovations in Climate Resilient Agriculture) action research project through real time contingency measures.

Materials and methods

Participatory trials were conducted on farmers' fields from 2011 to 2014 under the project, "National Innovations in Climate Resilient Agriculture" (NICRA) which is in operation at Chikkamaranahalli cluster comprising of Chikkamaranahalli, Chikkamaranahalli colony, Chikkaputtayyanapalya, Mudala-palya and Hosapalya of Nelamangala taluk, Bengaluru Rural

Table 1 : Rainfall and number of rainy days during 2011-2014

Period	Normal rainfall (mm)	Actual Rainfall (mm)			
		2011	2012	2013	2014
Summer (April-May)	119.1	137	92	110	106.0
		(6)	(4)	(9)	(6)
Kharif (June-October)	572.2	529	268	498	776.0
		(28)	(20)	(23)	(42)
Rabi (Nov-March)	58.7	26	82	35	12.0
		(2)	(2)	(3)	(2)
Total	750.0	692	442	643	894.0
		(36)	(26)	(35)	(50)
% deviation from normal rainfall		-7.73%	-41.22%	-12.41	+23.0%

Figures in parentheses are number of rainy days

district of Karnataka. Fields were selected based on the willingness of farmers to engage in participatory research to evaluate the science based strategy. Selection also ensured trials with all prominent crops in the domain. Capacity building of selected farmers was undertaken through repeated trainings in multi-disciplinary approach. Selected farmers participated in each and every research intervention like soil sampling, input application and yield estimation.

Major soils in the domain area are sandy loam to sandy clay loam with acidic to neutral reaction (pH 4.3 to 6.5). The area receives normal annual rainfall of 750 mm (Table 1). The rainfall during 2012-13 was scanty (-41.22 % deviations). The rainfall during *kharif* 2011 was normal (7.5% deviation). The deviation during *kharif* 2012 was -53.2% compared to the normal and impacted greatly on the crop production activities under conventional farming practices.

High yielding finger millet varieties

Wide array of finger millet varieties with different duration and season has been developed and released for cultivation (Table 2). But farmers still are growing long/ medium/ short duration finger millet varieties irrespective of the sowing time and reaping poor yield. Long duration (120-125 days) MR-1 for July sowing, medium duration (110-115 days) GPU-28 for August 1st fortnight sowing and short duration (100-105 days) GPU-48 for August 2nd fortnight sowing was demonstrated on 59, 57, 27 and 22 farmers' fields during 2011, 2012, 2013 and 2014, respectively.

Method of establishment in finger millet

Considering the tolerance of finger millet for transplanting shock, seedlings were raised in the nursery and transplanted to the main field at an age of 20-25 days as a contingency for delayed onset of monsoon was demonstrated over 59, 7, 36 and 4 farmers' field during 2011, 2012, 2013 and 2014, respectively. Direct sowing with same variety was taken up as control simultaneously.

Modified seed drill for finger millet sowing

The farmers in the domain area take up finger millet sowing either by broadcasting or by drilling with local seed drill (close spacing, 11 tones). Further, local seed drill is heavy necessitating three laborers for managing bullock and dropping the seeds. Also, it is closely spaced and difficult to carry out inter-cultivation posing a severe weed menace. Considering the

Table 2 : Recommended finger millet varieties for dryland areas of *Alfisols*

Variety	Duration (days)	Sowing time
MR-1	120-125	June-July
MR-6	120-125	June-July
L-5	115-120	June–July
HR-911	115-120	July
GPU-28	110-115	July- August
GPU-48	100-105	August-September
GPU-26	100-105	August- September

above difficulties, a light weight, 30 cm row spaced seed drill was designed for the convenience of sowing with less labour (2 No.) and facilitating inter cultivation. Sowing of finger millet using the modified seed drill was demonstrated in an area of 165 ha in farmers' field during 4 years of study along with farmers' practice as a control.

***In situ* moisture conservation through conservation furrow**

Presently, farmers follow *Akkadi* cropping (mixed cropping) system, i.e., 10-14 rows of finger millet or groundnut with one row of mixture of 5-9 crops like fodder sorghum, castor, mustard, sesame, cowpea, pigeon pea, field bean *etc*. Inter-plant competition and staggered maturity of crops pose yield decline besides posing difficult to harvest.

Under the improved practice, simultaneous sowing of groundnut or finger millet with pigeonpea in 8:2 row proportions with 60 cm spacing between the paired rows of pigeonpea and opening of conservation furrow between the paired rows of pigeonpea was adopted as a strategy for soil and moisture conservation over 54, 18, 17 and 46 farmers' field during 2011, 2012, 2013 and 2014, respectively.

The data on yield, economics were recorded adopting a standard procedure. The data were subjected to "t" test analysis for determining its significance between the treatments and to draw valid conclusions. The level of significance used was 5%.

Results and discussion

Finger millet varieties for different sowing window

Due to the regular onset (June 2nd) of monsoon during 2011, the long duration variety (MR-1) performed well. About 466 mm of rainfall was received during the cropping season with 5 dry spells (> 10 days). Among various finger millet varieties, long duration variety MR-1 sown on 22nd July (July 2nd fortnight) recorded higher grain yield (2,593 kg/ha) followed by medium duration variety (GPU-28) (2,556 kg/ha) sown on 5th August (August 1st fortnight). Under late sowing situation (August 2nd fortnight), a short duration variety GPU-48 recorded higher grain yield (2,580 kg/ha). Highest B:C ratio and rainwater use efficiency (2.48 and 5.59 kg/ha-mm, respectively) was obtained with cultivation of long duration variety MR-1. For delayed sowing GPU-28 (August) and GPU-48 (August-September) were suitable (Table 3).

In 2012, during the cropping season, 252 mm rainfall was received with four dry spells (> 10 days). Long duration variety (MR-1) of finger millet were recommended for sowing in July. Delayed onset of monsoon during *Kharif* 2012-13 forced to shift to medium duration variety (GPU-28), while the non-beneficiary farmers adopted long duration variety (MR-1 and Local) even under the late onset of monsoon and incurred huge losses.

Among the varieties, medium duration variety (GPU-28) sown in August first fortnight recorded higher grain yield, net returns and B:C ratio (1720 kg/ha, ₹ 21161/ha and 2.30, respectively) than long duration variety MR-1 (1555 kg/ha, ₹ 18096/ha and 2.11, respectively). RWUE was higher with GPU-28 (10.17 kg/ha-mm) as compared to MR-1 (6.17 kg/ha-mm). Due to delayed onset of monsoon, GPU-28 performed better than long duration variety MR-1 (Table 3).

Table 3 : Performance of drought tolerant varieties of finger millet under real time contingent crop planning

Treatments	DOS	Rainfall (mm)	Crop duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (₹/ha)	B:C ratio
				Grain	Straw			
2011								
MR-1 (Long duration)	22nd July	466	113	2593	5876	5.59	19634	2.48
GPU-28 (Medium duration)	5th Aug	270	105	2556	5960	11.47	19281	2.45
GPU-48 (Short duration)	21st Sept	192	95	2480	2980	12.9	16226	2.2
2012								
MR-1 (Long duration)	15th Aug	252	123	1555	4328	6.17	18096	2.11
GPU-28 (Medium duration)	31st Aug	169	115	1720	4015	10.17	21161	2.3
2013								
MR-1 (Long duration)	10th July	405	119	1967	4210	4.86	23510	2.24
GPU-28 (Medium duration)	19th Aug	326	108	1700	3947	5.21	17972	1.95
2014								
MR-1 (Long duration)	14th Jul	649	135	2238	3789	3.45	32122	2.35
GPU-28 (Medium duration)	2nd Sep	595	109	2100	3759	4.55	28684	2.2

DOS: Date of sowing; RWUE: Rain water use efficiency

In 2013, a rainfall of 405 mm was received with four dry spells (>10 days) during cropping season. The results of the demonstration indicated that, the long duration variety MR-1 recorded higher grain yield (1967 kg/ha), net returns (₹ 23510/ha) and B:C ratio (2.24) than medium duration variety GPU-28 (1700 kg/ha, ₹ 17972/ha and 1.95, respectively). RWUE was higher with GPU-28 (5.21 kg/ha-mm) as compared to MR-1 (4.86). Due to timely onset of monsoon (2nd June), MR-1 performed better than medium duration variety GPU-28.

In 2014, 649 mm rainfall was received with four dry spells (>10 days) during cropping season. Long duration variety (MR-1) recorded higher grain yield, net returns and B:C ratio (2238 kg/ha, ₹ 32122/ha and 2.35, respectively) due to July sowing than medium duration variety GPU-28 (2100 kg/ha, ₹ 28684/ha and 2.20, respectively). The RWUE was higher with GPU-28 (4.55 kg/ha-mm). Due to the timely onset of monsoon, MR-1 performed better than medium duration variety GPU-28. The yield and economics of medium duration variety were higher than long duration due to delayed monsoon and sowing. Ramachandrappa *et al.* (2010; 2013) also reported the similar results.

Transplanting of finger millet as a real time contingency measure for delayed onset of monsoon

In 2011, during the cropping season 366 mm rainfall was received with five dry spells (> 10days). Among different methods of establishment, finger millet (MR-1) seedlings raised in nursery and transplanted on 8th August recorded higher grain yield (2623 kg/ha) followed by finger millet directly sown on 22nd July (2172 kg/ha). Economics of transplanted and direct finger millet revealed that, transplanting recorded higher B: C ratio of 2.46 as against 2.09 in direct sown finger millet. Similarly, the RWUE was highest (8.01 kg/ha-mm) with transplanting (Table 4).

In 2012, during the cropping season 264 mm rainfall was received with four dry spells (>10 days). Due to delayed onset of monsoon, transplanted finger millet recorded higher grain yield (2255 kg/ha), net returns (₹ 28850/ha), B:C ratio (2.50) and RWUE (8.54 kg/ha-mm) as compared to direct sown finger millet (1857 kg/ha, Rs 23455/ha, 2.37 and 7.03, kg/ha-mm, respectively) (Table 4).

In 2013, during the cropping season 405 mm rainfall was received with four dry spells (>10 days). Transplanted finger millet (MR-1) recorded higher grain yield (2417 kg/ha), net returns (₹ 31465/ha), B:C ratio (2.72) and RWUE (9.19 kg/ha-mm) as compared to direct sown finger millet (1967 kg/ha, ₹ 23510/ha, 2.24 and 4.86 kg/ha-mm, respectively).

In 2014, transplanted finger millet (MR-1) recorded higher grain yield (2550 kg/ha), net returns (₹ 42713/ha) and B:C ratio (2.78) as compared to direct sown finger millet (2250 kg/ha, ₹ 35247/ha and 2.48, respectively). On an average, transplanting of finger millet recorded significantly higher finger millet yield (2461 kg/ha) compared to direct sowing (2062 kg/ha). In a situation with the normal onset of monsoon, direct sowing of finger millet variety MR-1 was found to be more remunerative than direct seeding of GPU-28 (Hegde and Jayarama Reddy, 1983 and Ramachandrappa *et al.,* 2013).

Table 4 : Establishment techniques in finger millet as real time contingent crop plan

Treatment	DOS/ DOT	No. of farmers	Rainfall (mm)	Crop duration (days)	Yield (kg/ha)		RWUE (kg/ha -mm)	Net returns (₹/ha)	B:C ratio
					Grain	Straw			
2011									
T_1	22th Jul	5	425	106	2172	5235	5.56	14519	2.09
T_2	08th Aug	6	366	102	2623	5126	8.01	19393	2.46
2012									
T_1	06th Aug	6	264	124	1857	4000	7.03	23,455	2.37
T_2	06th Aug	7	264	133	2255	5126	8.54	28,850	2.5
2013									
T_1	10th Jul	4	405	119	1967	4210	4.86	23510	2.24
T_2	28th Aug	5	263	102	2417	4417	9.19	31465	2.56
2014									
T_1	14th Jul	2	648	135	2250	3750	3.47	35247	2.48
T_2	14th Aug	4	594	108	2550	3950	4.29	42713	2.78
Mean									
T_1	-	4	441.	-	2062	4299	5.29	24183	2.30
T_2	-	6	372	-	2461	4655	7.51	30605	2.58
t-value for finger millet grain equivalent yield					7.35*				

T_1: Direct sown (MR-1); T_2: Transplanted (MR-1); DOS: Date of sowing; DOT: Date of transplanting; RWUE: Rain Water Use Efficiency

Modified bullock drawn seed drill for finger millet

Finger millet crop sown using modified bullock drawn seed drill recorded significantly higher grain yield (2417 kg/ha), net returns (₹ 35965/ha) and B:C ratio (3.21) as compared to farmer's practice (1770 kg/ha, ₹ 22173/ha and 2.36, respectively). The modified seed drill facilitated optimum plant population, ease of inter-cultivation and ultimately increased the yield (Table 5). These results are in accordance with Ramachandrappa *et al*. (2011) and Ramachandrappa *et al*. (2014). In the project area, most of the finger millet was sown using modified seed drill, which helped in timely sowing and hence the better crop establishment and higher yield.

***In-situ* moisture conservation through conservation furrow**

In 2011, *In-situ* moisture conservation through conservation furrow for improved yield in finger millet based production system was demonstrated in 46 farmers' fields. During the cropping season 621 mm of rainfall was received with 5 dry spells. Finger millet + pigeon pea in 8:2 ratio with conservation furrow was superior with maximum net returns (₹ 31534/ha), B:C ratio (3.10) and RWUE (6.22 kg/ha-mm) compared to the farmers' practice of finger millet + *akkadi* (fodder sorghum) (₹ 11989/ha, 1.90 and 3.97, respectively). The improved system recorded a finger millet equivalent yield of 3861 kg/ha, while farmers' practice recorded lower finger millet equivalent yield 1894 kg/ha (Table 6).

During 2012, 350 mm rainfall was received with four dry spells (>10 days). Under finger millet + pigeonpea in 8:2 ratio with conservation furrow, recorded higher finger millet equivalent yield, net return, B:C ratio and RWUE (2106 kg/ha, ₹ 28642/ha, 2.72, and 7.16 kg/ha-mm, respectively) as compared to farmers' practice (1770 kg/ha, ₹ 22173/ha, 2.36 and 6.08 kg/ha-mm, respectively) (Table 6). A similar trend of results was recorded during 2013 and 2014. On an average, the intercropping system of finger millet + pigeonpea (8:2) with conservation furrow between paired rows of pigeonpea recorded significantly

Table 5 : Comparison between modified bullock drawn seed drill and local seed drill for finger millet

Treatment	Rainfall (mm)	No. of Farmers	Crop duration (days)	Yield (kg/ha)		RWUE (kg/ ha-mm)	Net returns (₹/ha)	B:C ratio
				Grain	Straw			
Modified bullock drawn Seed drill	247	7	120	2417	5167	9.79	35965	3.21
Farmer's practice	247	4	120	1770	4030	7.16	22173	2.36
t-value for finger millet grain equivalent yield				5.38*				

RWUE: Rain water use efficiency

Table 6 : *In-situ* moisture conservation in finger millet + pigeonpea (8:2) intercropping system

Treatment	Rainfall (mm)	No. of farmers	Crop duration (days)	Finger millet equivalent yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ ha-mm)	Net returns (₹/ha)	B:C ratio
2011								
T_1	621	35	212	3861	5410	6.22	31534	3.1
T_2	477	12	121	1894	5940	3.97	11989	1.9
2012								
T_1	350	34	154	2106	4296	7.16	28642	2.72
T_2	247	11	120	1770	4030	6.08	22173	2.36
2013								
T_1	405	32	119	1973	4085	4.87	21936	2.07
T_2	390	10	112	1333	3000	3.42	9929	1.52
2014								
T_1	648	38	163	3056	4108	4.71	52586	3.12
T_2	650	13	130	2100	3900	3.22	28759	2.08
Mean								
T_1	501	35	-	2749	4475	5.74	33675	2.75
T_2	441	12	-	1774	4218	4.17	18213	1.97
t-value for finger millet grain equivalent yield				71.56*				

T_1: Finger millet + Pigeonpea with conservation furrow; T_2: Farmers' practice; RWUE: Rain water use efficiency

higher finger millet grain equivalent yield (2749 kg/ha) and B: C ratio (2.75) as compared to finger millet + akkadi (Table 6). Raikwar and Srivastva (2013) reported similar results. The increased yield and economics was associated with increased soil profile moisture as a result of conservation furrow. Also, intercropping of compatible crops benefit mutually in improving system productivity and returns. Finger millet and pigeonpea being different natured crops both above and below ground with different zones of nourishment. Also, pigeonpea being a leguminous crop helps for biological nitrogen fixation fulfilling the nitrogen needs of finger millet partly.

During 2011, groundnut + pigeonpea in 8:2 ratio with conservation furrow was superior with maximum net returns (₹ 40506/ha), B:C ratio (3.32) and RWUE (3.59 kg/ha-mm) compared to the farmers' practice of groundnut (sole crop) (₹ 816/ha, 1.06 and 0.95 kg/ha-mm, respectively). The improved system recorded higher groundnut equivalent yield of 2072 kg/ha compared to the farmers' practice of 547 kg/ha (Table 7). While, during 2012, 335 mm rainfall was received with six dry spells (> 10days). Compared to farmers' practice of groundnut (sole crop), Groundnut (TMV-2) + pigeonpea (TTB-7) in 8:2 ratio with conservation furrow was superior with maximum pod equivalent yield (718 kg/ha), net returns (₹ 17950/ha), B:C ratio (2.00) and rain water use efficiency (2.14 kg/ha-mm). While the farmers' practice of groundnut (sole crop) gave lower groundnut pod equivalent yield (382 kg/ha), net returns (₹ 1600/ha), B:C ratio (1.09) and rain water use efficiency (1.53 kg/ha-mm). Per cent increase in yield over farmer's practice was 9.42 (Table 7). Similar observations were made during 2014 with 720 mm rain fall and five dry spells (> 10days). On an average, the intercropping system of groundnut + pigeonpea (8:2) with conservation furrow between paired rows of pigeonpea recorded significantly higher groundnut equivalent yield (1347 kg/ha) and B:C ratio (2.49) compared to sole groundnut (473 kg/ha and 1.09, respectively). The advantage of having conservation furrow between two rows of pigeonpea in groundnut + pigeonpea (8:2) intercropping has been reported by Ramachandrappa *et al*. (2011). These results indicated the worthiness of *in-situ* moisture conservation through conservation furrow between paired rows of pigeonpea in realizing higher yield of groundnut and economic returns.

Table 7 : *In situ* moisture conservation in groundnut + pigeonpea (8:2) intercropping system

Treatment	Rainfall (mm)	No. of farmers	Yield (kg/ha)		Groundnut equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (₹/ha)	B:C ratio
			Groundnut	Pigeonpea				
2011								
T_1	577	11	792	913	2072	3.59	40,506	3.32
T_2	574	2	547	-	547	0.95	816	1.06
2012								
T_1	335	9	418	375	718	2.14	17950	2.00
T_2	249	2	382	-	382	1.53	1600	1.09
2014								
T_1	720	7	977	382	1251	1.74	40317	2.16
T_2	720	2	489	-	489	0.68	3340	1.13
Mean								
T_1	544	9	729	557	1347	2.49	32924	2.49
T_2	381	2	473	-	473	1.05	1919	1.09
t-value for finger millet grain equivalent yield					26.52*			

T_1: Groundnut + pigeonpea with conservation furrow; T_2: Farmer's practice (Sole groundnut); RWUE: Rain water use efficiency

Conclusions

Real time contingency crop planning for aberrant rainfall situations plays a crucial role in dryland agriculture for sustaining the productivity and livelihood of farmers in the eastern dry zone (Zone-5) of Karnataka under predominant finger millet and groundnut based cropping systems. Selection of variety according to the sowing window, transplanting method of establishment under delayed rainfall conditions, *in-situ* moisture conservation through conservation furrow between pigeonpea rows in finger millet + pigeonpea (8:2) and groundnut + pigeonpea (8:2) intercropping systems, use of modified seed drill for optimum plant population and quicker establishment in finger millet would enhance the productivity, RWUE and economic benefits to the dryland farmers in *Alfisols*.

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