National Innovation in Climate Resilient Agriculture – A Case Study at Bangalore Rural district of Karnataka

ABSTRACT

Lower yield in dryland conditions is often associated with drought. Eastern dry zone of Karnataka, dominated with arid and semi-arid climate is characterized with predominant drought which is conjugated with reduced rainfall intensity and intermittent dry spells measures to overcome upgraded agricultural practices such as appropriate varieties, scientific methods of crop establishment, *in-situ* moisture conservation techniques and *ex-situ* rain water harvesting and its productive utilization was demonstrated from 2011 to 2019 at farmers field of Chikkamaranahalli cluster finger millet varieties sown under different sowing windows long duration (MR-1) for July sowing, medium duration (GPU-28) for August first fortnight sowing, short duration (GPU-48) for August second fortnight sowing performed well opening of in-situ moisture conservation furrows in between paired rows of pigeonpea in finger millet + pigeonpea (8:2) and groundnut + pigeonpea (8:2) inter cropping system recorded higher yield than that of farmers practice. Among the different crop establishment techniques transplanting of finger millet and sowing using modified bullock drawn seed drill resulted in superior yield over broadcasting. Thus climate resilient practices along with timely advisory services helped in maintaining sustainability.

Keywords: Climate resilient practices, In-situ moisture conservation, Real time agro advisory, sustainability

1. INTRODUCTION

In India, rainfed agriculture plays an important role both in terms of economy and rural livelihood out of 141 Mha of net sown area in the country, 80 Mha is rainfed (Srinivasa Rao *et al*., 2013). Modern agriculture is threatened most with changing climatic situations which affects the sustainability. Hence, the world/ agriculture system demands constant efforts to understand and adopt contingent agriculture practices for sustainable crop production.

Weather is the most important predominant factors affecting agricultural production, rainfall intensity and distribution is proved to be vital factors affecting crop production. Variation in rainfall such as delayed onset of monsoon, excessive rains and prolonged dryspell affects not only crop growth but also quality and quantity of produce thus following contingent measures at right time and condition based on weather forecast helps in reducing crop losses (Ramachandrappa *et al*., 2018).

India is more vulnerable to climate change, reports states that excessive pressure on natural resource has led to significant negative impact. Medium term climate change (2010-2039) has predicted to reduce yield by 4.5 to 9 % which is estimated to contribute 1.5 % GDP per year (Jasna *et al*., 2014).

Thus, keeping all these facts to improve sustainable agriculture under dryland situation. ICAR brought in major project National Initiative on Climate Resilient Agriculture (NICRA) during XI plan in February which focused on complex challenges faced in crop production, on long term basis. The main objective of the initiative was to demonstrate/ promote climate resilient technologies in agriculture *viz*., strategic research, demonstration of innovative and risk negative technologies, capacity building to stake holders. Similarly, price support system and marketing infrastructure to reduce price related risks to farmer (Panjab Singh, 2016) at farmer's field. Hence present investigation was carried out at Chikkamaranahalli village cluster of Bengaluru rural district, Karnataka.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

Adaptation refers to 'adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts' (Smit *et al*., 2000). (NICRA)" funded by ICAR–Central Research Institute for Dryland Agriculture (CRIDA) was conceptualized for Chikkamaranahalli cluster (Chikkamaranahalli, Chikkamaranahalli colony, Chikkaputtayyanapalya, Mudalapalya and Hosapalya), Nelamangala Taluk, Bengaluru Rural district since 2011 to till date. Farming constraints were identified through participatory rural appraisal (PRA) and the interventions for resilience were planned based on the constraints. Farmers' willingness to participate in participatory research to evaluate science-based practises was used to pick fields. Trainings in a multidisciplinary manner were used to develop the capacity of selected farmers. All research interventions, including as soil sampling, input application, and yield estimate, were carried out with the participation of farmers. The climate resilient agriculture practices, *viz*. selection of crops and cropping systems, improved varieties, rainwater harvesting and timely agriculture operations through farm mechanization were demonstrated. Delayed onset of monsoon and intermittent dry spells prevailed in the domain.

Rainfall pattern at experimental sites:
The area receives normal rainfall of 750 mm with highly erratic distribution. The prime objective of the project is to minimize the risk of rainfed crop production through implementation of real time contingency practices in relation to prevailing climatic situations. Before the demonstration, a list of farmers was compiled at a group meeting, and the farmers who were chosen received specific skill training. From soil sample until harvest, selected farmers took part in every research intervention. Calendar of operations were carried out as per the instructions of scientists and farmers' practice as control treatment was included for comparison. Based on the PRA and benchmark survey, technical interventions were taken up under different themes to address the climate vulnerability through suitable interventions in project area.. Major soils in the domain area are sandy loam to sandy clay loam in texture with acidic to neutral reaction (pH 4.3 to 6.5). Bimodal rainfall prevailed in the domain with peaks during May and Sept – Oct and its major share was during *Kharif* season. Required data was recorded and were converted in to quantitative form. Finally per cent increase in yield; technology gap, extension gap and benefit-cost ratio were calculated by using the formula given by Samui *et al*. (2000)

Per cent increase in yield $= \frac{(\text{Grain yield under improved practice} - \text{Grain yield under farmers practice})}{\text{Grain yield under farmers practice}} \times 100$

Technology gap = Potential crop yield - Crop yield under demonstration

Extension gap = Crop yield- under demonstration – Crop yield under farmers' practice

The maximum yield of crop obtained at the research station with favorable weather and crop management practices were accounted as potential yield. While, the maximum yield noticed in the farmers' field during the demonstration is counted for demonstration yield.

The SYI of different intercropping systems was calculated following the equation suggested by Sharma *et al*., 2004

Sustainability yield index (SYI) $= \frac{(A-SD)}{Ymax}$

Where, A = Average yield over the years for a particular treatment

SD = Standard deviation for the treatment

Ymax. = Maximum yield obtained of the treatment over the years.

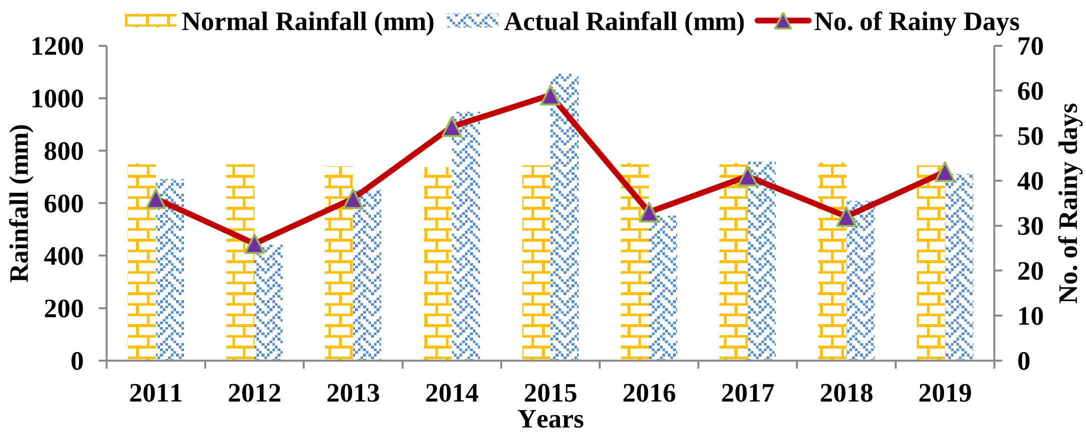

Fig.1: Normal v/s Actual Rainfall during the study period

Climate resilient Practices:

1. **Varietal demonstration in finger millet varieties:** Finger millet cultivars of various lengths and seasons have been produced 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.
2. **Establishment techniques in finger millet:** Seedlings were developed in the nursery and transplanted to the main field at an age of 20-25 days as a contingency for delayed beginning of monsoon from 2011-2012 to 2019-2020, taking into account finger millet us tolerance for transplanting shock. Simultaneously, direct seeding of the same variety was used as a control. **Technique *for In situ* moisture conservation**
3. **Farmers now use the Akkadi cropping (mixed cropping) system, which consists of 10-14 rows of finger millet or groundnut and one row of a mix of 5-9 crops such as fodder sorghum, castor, mustard, sesame, cowpea, pigeon pea, field bean, and so on. Inter-plant competition and staggered crop maturity reduce yields while also making harvesting more challenging. 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 the conservation furrow between the paired rows of pigeonpea after 25-30 days after sowing was adopted as a soil and moisture conservation strategy under the effective practices. Pulse based cropping system:

Simultaneous sowing of pigeonpea and field bean/cowpea in 1:1 row ratio at 90 cm × 22.5 cm and a short duration photo-insensitive field bean / cowpea in 1:1 row proportion (additive series). Maintaining three feet distance between the rows of pigeonpea without losing the main crop. As pigeonpea is a long duration crop and slow growing in early stages, growing of field bean/cowpea as additive series increases the land use productivity.

4. **Drill sowing of finger millet:** The farmers in the domain used to sow finger millet either by broadcasting or by drilling with local seed drill. Further, local seed drill is heavy in weight necessitating three laborers for handling bullock and dropping of seeds. Also, seeds are closely spaced which led difficulty to carry inter-cultivation operations posing a severe weed population. Considering the above difficulties, a light weight, 30 cm row spaced wooden seed drill was designed for the convenience of sowing with less labour (2 No.) and ease the inter cultivation operation.
5. **Recharging of borewell in filter bed system:** During autumn 2012-14, the experiment was set up at Hosapalya, Nelamangala Taluk, Bengaluru rural district was made under NICRA project to record the influence of recharging by feeding the excess runoff water to the low yielding borewell with filter bed system. A pit of 3m × 3m × 2.9 m dimension was excavated in the region centering the borewell casing. At the bottom of the pit, holes were drilled in a casing pipe and nylon mesh was tightly wrapped around it, allowing the casing pipe to act as a filter (Ramachandrappa et al., 2013). Different layers of filter bed material were set out according to the following specifications, as shown in Figure 2. The recharge hole was used to divert runoff water from the catchment for artificial recharging. Rainfall and runoff events were recorded using normal procedures in the various locations. After filling the filter bed recharge pit, the borewell yield was measured at 15-day intervals by collecting water in a measurement tub per unit time, and the discharge was computed using Michael and Ojha's standard approach (2014).

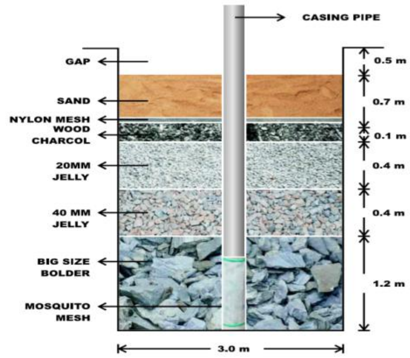

Fig 2. Different layers of filter bed material used in borewell recharge model

6. ***Agro*-Advisory Services and Crop related Weather Bulletins:** are issued twice a week (Tuesdays and Fridays) in collaboration with AICRPAM and IMD. Messages were written on boards at milk collection centers of Chikkaputtayanapalya and Hosapalya for the benefit of farmers in and around the villages. Instructions on rainfall, cloudy weather and dryspell were effectively used for carrying agricultural operations and was helpful in reducing the impairment. For assessing the impacts of agro-advisory services, the farmers using the agro-advisory services were selected. A questionnaire including climatic anomalies largely influencing crop production, source and frequency of weather forecast received by the farmers, features and qualities of agro advisory bulletins and willingness of the farmers to pay for the services, was prepared. Sample survey was conducted and 35 farmers were interviewed. The study area consisted of NICRA adopted villages in Chikkamaranahalli Cluster, Nelamangala taluk Bangalore Rural District.

3. RESULTS AND DISCUSSION

Varietal demonstration in finger millet varieties

Regular onset of monsoon was observed during the study period (2011-19) except during 2012 and 2017 which resulted in higher grain yield, net returns and B:C ratio with long duration finger millet variety (MR-1) sown during July. Delayed onset of monsoon during 2012 and 2017, the agro-advisory suggested the farmers to adopt a medium duration variety (GPU- 28) for delayed sowing in August. Farmers adopting the medium duration variety (GPU-28) realized an average higher grain yield of 1992 kg/ha, compared to the long duration variety (MR-1,1782 kg/ha). Delayed sowing of long duration variety pose end-season moisture stress on plants and arrested under low temperature during flowering and results in decreased yield. In a situation with normal onset of monsoon, direct sowing of finger millet variety MR-1 was found to be more profitable than direct sowing of GPU-28 (Hegde and Jayarama Reddy, 1983).

Transplanting of finger millet:

Finger millet tolerates transplanting shock and works as a contingency measure for delayed onset of monsoon. Transplanting of finger millet recorded significantly higher average finger millet grain yield (2442 kg/ha) and SYI (0.90) over the years compared to direct sowing (2091 kg/ha and 0.76 respectively). Maintaining optimum plant population, timeliness in flowering and maturity are the causes for higher yield (Ramachandrappa *et al*., 2013).

Moisture conservation furrow in finger millet based intercropping system:

Opening of moisture conservation furrow between paired rows of pigeonpea in finger millet + pigeonpea (8:2) intercropping system recorded higher average finger millet grain equivalent yield of 2714 kg/ha, higher net returns of Rs. 41689 /ha and B: C ratio of 2.60 as compared to farmers' practice (Table 3). The average additional equivalent yield under improved technology was 898 kg/ha which is 49.4 % higher over farmers practice. The additional net return recorded was Rs. 22,705 /ha. Finger millet + pigeonpea (8:2) intercropping system recorded higher value of sustainable yield index (0.76) over farmer's practice (0.35). The technology gap was 2.86 q/ha. Technology gap implies researchable issues for realization of potential yield while extension gap implies what can be achieved by the transfer of existing technology. The increased yield and economic benefit was associated with increased soil profile moisture as a result of conservation furrow (Raikwar and Srivastva, 2013). Finger millet and pigeonpea are crops with contrasting plant architecture both above and below ground. The root systems with different zones of nourishment exhibit complementarity; also pigeon pea being a legume helped the companion crop through biological nitrogen fixation.

Groundnut + Pigeonpea (8:2) Intercropping System for Higher Productivity

Groundnut + pigeonpea (8:2) intercropping system with a moisture conservation furrow between paired rows of pigeonpea recorded higher average groundnut equivalent yield (1640 kg/ ha) and economic returns (Rs. 24,960 /ha), B:C ratio (2.19) compared to farmers' practice (Table 4). The average additional equivalent yield under improved technologies over farmers' practice was 624 kg/ha, which is 61.4% higher over farmers' practice. Higher value of sustainable yield index was recorded for 8:2 groundnut + pigeonpea (0.73) over farmers' practice (0.35). The technology gap of 3.60 q/ha and extension gap of 6.24 q/ha. 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 were in conformity with the findings of Arjun Prasad and Ratan Singh (1998) and Raikwar and Srivastva (2013).

Pigeonpea + Fieldbean (1:1) Intercropping System

Introduction of pigeonpea + field bean (1:1) intercropping system resulted in higher pigeonpea average grain equivalent yield (1047 kg/ha), returns (Rs. 20472 /ha) and B: C ratio (1.68) compared to sole crop of pigeonpea (608 kg/ha, Rs.9145 /ha and 1.22, respectively, Table 5). The value of sustainability yield index recorded for pigeonpea + field bean (0.81) was higher compared to farmer's practice of growing pigeonpea as sole crop (0.39). Ramachandrappa et al. (2014 and 2015) also reported similar results.

Modified Bullock Drawn Seeddrill for Finger millet

Finger millet crop sown using modified bullock drawn seed drill recorded average higher grain yield (2281 kg/ha), net returns (Rs. 37426/ha) and B:C ratio (2.50) as compared to farmer's practice (1829 kg/ha, 249928/ha and 1.50, respectively). The modified seed drill facilitated optimum plant population, ease of inter-cultivation and helped in achieving higher yield (Table 6). These results are in accordance with Ramachandrappa *et al*. (2011, 2014 and 2016).

Recharging of Borewell in Filter Bed System:

The discharge rate of a borewell with filter bed during 2012-13, was on an average of 8.87 lpm. After implementing recharge treatment, over the year discharge rate of bore well with filter bed was 9.7 ltr. min^{-1} and in the rainy season, the average discharge rate was 10.87 lpm while 8.1 lpm in summer season. The discharge rate was increased with the advancement of monsoon and declined towards its cessession.

Agromet Advisory Services

Weather forecasts and weather-based agromet advisories assist farmers in increasing their economic advantage by recommending appropriate management methods depending on weather conditions. As a result, research was conducted on the modification of the agromet advisory bulletin as well as the economic impact of agromet advisory services. Farmers who followed the agromet advice reaped significant benefits, according to the economic impact analyses. The percent increase in yield owing to the implementation of suggested contingency cropping systems over traditional cropping systems ranged from 15.8 to 72.3. The yield increase in cropping systems *viz*., finger millet + pigeonpea, groundnut + pigeonpea, and pigeonpea + field bean was to the tune of 898, 624 and 435 kg ha-1, respectively. Transplanting of finger millet registered higher yield as contingency measure. Raje gowda *et al*. (2008) and Ramachandrappa *et al*. (2018) reported similar results that, in the eastern dry zone of Karnataka the farmers who have adopted the agromet advisories have realized additional benefit. Hence, it can be seen that the agro advisory information communicated to farmers in NICRA villages was useful to the farmers. Majority of farmers who followed the weather related agromet advisories were able to reduce the crop losses.

Table 1: Yield and economics of different finger millet varieties (mean of 2011-2019)

Year	Grain yield (kg/ha)	Net Returns (Rs. / ha)	B:C ratio
MR-1 (Long duration)	2224	32226	2.38
GPU-28 (Medium duration)	2081	29810	2.28
GPU-48 (Short duration)	2338	45330	2.68
S.Em.±	3.40	-	-
CD (p=0.05)	10.21	-	-

Table 2: Performance of finger millet under different establishment methods

Method of establishment	Grain yield (kg/ha)	Net Returns (Rs./ ha)	B:C ratio	SYI	Percent increase in yield	Technology gap	Extension gap
Transplanting	2422	35352	2.52	0.90	15.8	578.4	330.6
Direct sown	2091	29130	2.31	0.76	-	909.0	-

Table 3: Yield (kg/ha) and economics (Rs. / ha) of finger millet + pigeonpea (8:2) cropping system (Mean of 2011-2019)

Treatment	Finger millet equivalent Yield (kg/ha)	Net Returns (Rs./ ha)	B:C ratio	SYI	% increase in yield	Technology gap	Extension gap
Improved practice	2714	41689	2.6	0.76	49.4	286	898
Farmer's practice	1816	18984	1.7	0.43	-	1184	-

Table 4: Yield (kg/ha) and economics (Rs. / ha) of groundnut + pigeonpea (8:2) cropping system (mean of 9 years)

Treatment	Groundnut equivalent Yield (kg/ha)	Net Returns (Rs./ ha)	B:C ratio	SYI	Percent increase in yield	Technology gap	Extension gap
Improved practice	1640	44359	2.3	0.73	61.4	360	624
Farmers practice	1016	4843	1.2	0.35	-	984	-

Table 5: Yield (kg/ha) and economics (/ ha) in pulse based production system (mean of 9 years)

Treatment	Pigeonpea equivalent Yield (kg/ha)	Net Returns (Rs./ ha)	B:C ratio	SYI	Percent increase in yield	Technology gap	Extension gap
Pigeonpea + cowpea	965	32820	2.07	0.73	58.7	235.2	356.9
Pigeonpea + field bean	1047	40733	2.32	0.81	72.3	152.8	439.4
Sole pigeonpea	608	13711	1.47	0.39	-	592.1	-
S.Em.±	7.95	-	-	-	-	-	-
CD (p=0.05)	23.83	-	-	-	-	-	-

Table 6: Benefit of modified bullock drawn seed drill for sowing of finger millet

Treatment	Finger millet Yield (kg/ha)	Net Returns (Rs./ ha)	B:C ratio	SYI	% increase in yield	Technology gap	Extension gap
With improved implement	2162	34161	2.43	0.87	20.8	755	193
Without improved implement	1773	17738	1.72	0.82	-	1141	-

Table 7: Impact of agro advisory services on productivity and economics of cropping systems (mean of 9 years)

Crops/ cropping system	AAS farmers			Non AAS farmers			Additional income to AAS farmers	% gain in yield over Non AAS farmers
	Yield (kg/ha)	Returns (Rs./ha)	B: C ratio	Yield (kg/ha)	Returns (Rs./ha)	B: C ratio		
Transplanting of finger millet	2422	35352	2.52	2091	29130	2.31	6222	15.8
Finger millet + pigeonpea (8:2)	2714	41689	2.6	1816	18984	1.7	22705	49.4
Pigeonpea + cowpea (1:1)	965	32820	2.07	608	13711	1.47	19109	58.7
Pigeonpea + field bean (1:1)	1047	40733	2.32	608	13711	1.47	27022	72.3
S.Em.±	17.37	-	-	13.14	-	-	-	-
CD (p=0.05)	53.52	-	-	40.50	-	-	-	-

4. CONCLUSION

Sustainable dryland practices *viz*., moisture conservation furrow in finger millet + pigeonpea (8:2) and groundnut + pigeonpea (8:2) intercropping, intercropping of pigeonpea + field bean (1:1), adoption of improved varieties of fingermillet according to the sowing window, INM in fingermillet proved superior in improving productivity and over the year of its existence, agro advisory services had established sufficient credibility and reliability among the farming community. The farmers adopted the free advice given through the service and also realized benefits, hence improving the livelihood of dryland farmers.

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