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Climate - Resilient Technology to Adapt to Climate Change for Sustainable Livelihood and Production

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Abstract

In the five most climatically vulnerable districts of Alappuzha in Kerala and Gadag, Kalaburagi, Tumakuru and Chikkaballapura in Karnataka, climate resilient technologies such as the selection of climate resilient varieties, location specific intercropping systems and goat management were demonstrated during 2021. Selection of improved varieties *viz.*, finger millet (ML-365), maize (MAH-14-5), sorghum (SPV 2217) and pigeonpea (BRG-5) performed better with yield of 20.30 q/ha, 27.10 q/ha, 22.75q/ha and 9.30 q/ha, respectively than local varieties. Ground nut + pigeonpea (13.40 q/ha), maize + pigeonpea (71.95 q/ha), green gram + pigeonpea (8.63 q/ha), pigeonpea + black gram (12.25 q/ha) and finger millet + pigeonpea (20.7 q/ha) intercropping systems recorded significantly higher yields compared to their sole crops (12.57 q/ha, 53.97q/ha, 6.25 q/ha, 4.90 q/ha and 20.1 q/ha, respectively). Improved goat shelter with raised platform, reduced the mortality from 40 per cent to 0 and increased number of kids per year (17 kids/ year) with net return of Rs.57345/- and B:C ratio of 1.7 compared to traditional goat rearing shelter.

Keywords : Climate change, Climate resilient, Climate vulnerable, Intercropping system

Climate change and its variability have emerged as serious concerns to Indian agriculture in recent years. Global climate change projections include increased extreme events (*e.g.,* heat and cold waves, flooding), increased atmospheric carbon dioxide and ground-level, ozone concentrations and a rise in sea level that will inundate coastal areas, among other things (Raghavan *et al.,* 2020). Climate change can reduce agricultural income by 15 to 25 per cent. Hence, it is right time to value and execute climate-resilient agriculture more rigorously. Planned approaches to adaptation in agriculture and development practices are necessary to cope with climate change and make agri-production resilient to climate changes and shocks. India has a diverse ecology and some regions have evolved and adapted practices over time to tackle vagaries. Judicious use of some of these practices has the potential to mitigate the effects of climate change. Proper management and implementation of practices that have resulted in an increased agri-produce in unfavourable conditions can also be used to adapt to climate change. These practices lead to increased resilience and consistency in yield despite varying climatic conditions.

Climate-resilient crops and crop varieties have enhanced tolerance to biotic and abiotic stresses. They are intended to maintain or increase crop yields under extreme weather conditions and thereby provide a means of adapting to diminishing crop yields in the face of droughts, higher average temperatures and other climatic conditions (Maricelis Acevedo *et al*., 2020). Adoption of

climate-resilient crops, such as short duration crop varieties, heat-tolerant varieties, drought tolerant and resistant cereal, legumes or varieties with enhanced salinity tolerance or rice with submergence tolerance, can help farmers to better cope with climate shocks.

Intercropping is an important aspect to combat the crop failure in rainfed agriculture under the situation of climate change and helps in improving productivity and profitability through efficient utilization of natural resources. Intercropping provides insurance against drought, modifies soil environment, improves moisture and radiation use, ensures better weed control, reduces disease and pest incidence and on the whole increases and stabilizes the productivity. Intercropping has been identified as a kind of biological insurance against risks under aberrant rainfall behavior. Crop diversification is also necessary to get higher yield and return besides maintaining soil health apart from other benefits (Siddique *et al.,* 2012)

By adopting new technology and innovative measures for crops and livestock production, farmers are more inclined to adapt their sustainable livelihoods to mitigate the impact of precipitation deficits and climate shocks. It ensures the farmers' income becomes more resilient, not only from the short-term climate shocks but also in the long run by producing crops that are resilient to drought and weather variability (Adiqa Kausar Kiani *et al.* 2021). In this regard, study was undertaken to evaluate different climate resilient technologies *viz.,* improved and drought resistance varieties, location specific intercropping system and livestock management technology in selected NICRA villages of Karnataka and Kerala.

Material and Methods

The participatory trials were undertaken in farmers' fields during 2021 under the 'National Innovations in Climate Resilient Agriculture' (NICRA) project which is in operation in five most climatically vulnerable districts namely Alappuzha in Kerala and Gadag, Kalaburagi, Tumkuru, Chikkaballapura in Karnataka. Table 1 shows the villages that were chosen for the study, as well as the soil types, normal rainfall and climatic vulnerabilities.

The demonstration of climate resilient varieties, location specific intercropping system and goat management conducted in selected farmer's field. 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.

Climatic Conditions

During 2021, among the climate vulnerable districts the highest annual rainfall was recorded

Table 1

Selected NICRA village information

NICRA village	Taluk and District	Annual rainfall (mm)	Soil type	Climate variability
Edathua	Alappuzha, Kerala	2928.3	Clayey alluvial	Flood/water inundation
Suntanoor	Aland taluk, Kalaburgi	782.9	Medium deep black clayey soil	Drought
Chikkadoddavadi	Korategere taluk, Tumkuru	697	Red sandy soil	Drought
Singatarayanakeri	Mundaragi taluk Gadag	641.6	Red gravel	Drought
Hanumaigarahalli	Chintamani taluk, Chikkaballapura district	703.2	Red loamy soil	Drought

TABLE 2
Climatic conditions of the NICRA village

NICRA village	Rainfall (mm)		Rainy days	Dry spell	Intensive rain (> 60 mm)
	Normal	Actual			
Edathua, Alappuzha, Kerala	2928.3	3610.2	109	-	8
Suntanoor, Aland taluk, Kalaburgi	782.9	1179.1	53	1	4
Chikkadoddavadi Korategere taluk, Tumkuru	697.0	1097	252	6	3
Singatarayanakeri, Mundaragi taluk Gadag	641.6	612.8	33	5	2
Hanumaigarahalli, Chintamani taluk, Chikkaballapura district	703.2	1322.4	57	-	2

in NICRA village of Alappuzha district of Kerala with 3610.2 mm (109 rainy days) as against normal rainfall of 2928.3 mm. Eight intensive rain spells of more than 60 mm occurred during the months from June to December. In NICRA village of Kalaburgi district received an annual rainfall of 1179.1 mm as against normal rainfall of 782.9 mm and Tumkur district received annual rainfall of 1097 mm with six dry spells and also three intensive rain spells of more than 60 mm occurred in the months of October and November. In Gadag, 5 dry spells with annual rainfall of 612.80 mm (33 rainy days) was recorded as against normal rainfall of 641.60 mm in Singatarayanakeri village. In total it was 4.67 per cent deficit from the normal rainfall. Hunumaigarahalli village, Chikkaballapura district recorded 1322.4 mm with 57 rainy days as against normal rainfall of 703.21mm, with two intensive rain spells of more than 60mm occurred (Table 2).

Climate Resilient Varieties

Farmers are still growing local and long duration varieties which are low productive and often crop failures are experienced either due to rainfall extremes or disease occurrence. During 2021, high yielding short duration varieties and drought resistant varieties of finger millet, sorghum, pigeonpea and maize were demonstrated in 63 farmer's field covering on area of 32.5 ha at climatically vulnerable districts of Karnataka *(*Tumkur, Gadag, Kalaburgi and Chikkaballapura).

Improved Intercropping System

Famer's practice sole cropping but is risky and often results in low yields or sometimes even in crop failure due to erratic monsoon rainfall and skewed distribution. Considering climatic and other risk, during 2021, location specific intercrop cropping system like finger millet + pigeonpea, groundnut + pigeonpea, maize + pigeonpea, green gram + pigeonpea and pigeonpea + blackgram were demonstrated in 66 farmers field covering an area of 33.6 ha at climatically vulnerable districts *viz.,* Tumkur, Gadag, Kalaburgi and Chikkaballapura.

Goat Shelter with Raised Platform

Kuttanad region of Kerala, a unique ecosystem which lies up to 2 m below Mean Sea Level (MSL), is often susceptible to submergence during the South-West monsoon period (June-Sept). In these conditions if farmers follow traditional goat shelters with a flank constructed of country wood stored at ground level will be submerged during June to September and farmers get only 7-8 months/ year for goat rearing. Considering these problems, during 2021-22 goat shelter with raised platform and scientific management practices for goat rearing were introduced as technology demonstrations in 13 farmer's field at Edathua, Alappuzha, Kerala. The data on yield, economics and other parameter were recorded adopting a standard procedure.

Results and Discussion

Climate Resilient Varieties

During 2021, a rainfall of 967 mm was received with six dry spells and three intensive rainfall spell (October and November) during cropping season in NICRA village at Tumkuru district. The results showed that the short duration finger millet variety ML-365 recorded an average yield advantage of 20.30 per cent and a benefit cost ratio of 1.84 as compared to other local varieties in the village and high yielding as well as drought resistant maize hybrid MAH-14-5 recorded higher grain yield, net returns and B:C ratio (27.1q/ha, Rs.18688/ha and 1.77, respectively) as compared to local varieties (20.9q/ha, Rs.9842 and 1.42). The yield and economics of medium duration varieties were higher than other local and long duration varieties due to medium and short duration varieties ability to avoid the heavy rains that occurred in November. Ramachandrappa *et al.* (2016) also reported the similar results (Table 3).

Chikkaballapura NICRA village had 384.9 mm and 275.7 mm of rainfall in October and November of 2021, respectively. Pigeonpea variety BRG-5 performed better in severe rainfall conditions with an average grain yield of 9.13q/ha and higher net returns (Rs.26810/ha) and B:C ratio (7.86) than other local varieties in the NICRA village (Table 3).

NICRA village at Kalaburgi, during the cropping season received 1179.1 mm rainfall with one dry spell (> 20 days) in August and four intensive rainfall spell (> 60mm). In *Rabi* season, sorghum variety SPV 2217 recorded higher grain yield (22.75 q/ha), net returns (Rs.37450/ha) and B:C ratio (2.42) as compared to other local varieties (18.50 q/ha).

Location Specific Intercropping System

Finger millet, pigeonpea, groundnut, maize and green gram are the main crops cultivated in NICRA village in Chikkaballapura, Tumkuru, Gadag and Kalaburgi districts of Karnataka which are affected due to late onset of monsoon followed by dry spell and intensive rainfall at critical crop growth stages (Table 4). Intercropping has been identified as a kind of biological insurance against risks under aberrant rainfall behavior (Thimmegowda *et al.,* 2016) and intercropping system is best crop diversification for livelihood security and resilience to climate variability

In Chikkaballapura district, groundnut + pigeonpea (8:2) intercropping systems recorded higher groundnut equivalent yield 13.40 q/ha with higher benefit cost ratio (1.61). The increase in yield might be due to no or low competition between main crop and intercrop for growth, development and for above ground and below ground resources as groundnut crop was of shorter duration and non-spreading nature and further, might be due to complementarity

Table 3

Performance of climate resilient varieties in different climate vulnerable districts of Karnataka

Climate vulnerable district	Crop	Treatment	Area (ha)	Farmers (No.)	Yields (q/ha)	Increase (%)	Net return (Rs./ha)	B:C
Tumkur	Finger millet	ML-365	11.0	9	20.3	20.83	20785	1.84
	Local variety		1	2	16.8	-	13670	1.57
Tumkur	Maize	MAH-14-5	2.0	3	27.1	29.67	18688	1.77
	Local variety		0.5	1	20.9	-	9842	1.42
Kalaburgi	Sorghum	SPV 2217	12.0	30	22.75	22.97	37450	2.42
	Local variety		2	10	18.50	-	26750	2.07
Chikkaballapura	Pigeonpea	BRG-5	4.0	8	9.30	14.11	26810	1.86
	Local variety		1	3	8.15	-	20580	1.68

TABLE 4

Performance of improved intercropping system in different climate vulnerable districts of Karnataka

Climate vulnerable district s	Treatment	Area (ha)	Farmers (No.)	MCEY (q/ha)	Increase (%)	Net return (Rs./ha)	B:C
Chikkaballapura	Groundnut + pigeonpea	8.0	15	13.40	6.60	64356	1.61
	Groundnut	6	10	12.57	-	17372	1.40
Gadag	Maize+ pigeonpea	6.0	15	71.95	33.31	54542	2.18
	Maize	2.0	5	53.97	-	36327	1.93
Gadag	Greengram + pigeonpea	2.0	5	8.63	38.08	32403	2.27
	Greengram	1.0	4	6.25	-	21100	2.01
Kalaburgi	Pigeonpea + blackgram	10.0	25	12.25	150.00	35250	1.81
	Pigeonpea	2.0	6	4.90	-	12850	1.67
Tumkur	Finger millet + pigeonpea	7.6	6	20.7	2.99	21457	1.85
	Finger millet	10	12	20.1	-	20466	1.83

MCEY = Main crop equivalent yield

in resource utilization by groundnut crop (Ramesh and Devasenapathy, 2007).

Diversification of maize and green gram cropping based systems by intercropping with pigeonpea may foster productivity and resilience to adverse weather conditions. Maize + pigeonpea and greengram + pigeonpea recorded higher maize (7.95q/ha) and greengram (8.63 q/ha) equivalent yield with higher net return and B:C ratio compared to their sole crops in NICRA village at Gadag district. Leah L.R. Renwick *et al*., 2020 reported that, maize + pigeonpea was the only intercrop that consistently required less land than its sole maize to produce the same yield particularly under drought. Despite intercropping systems having greater planting density than sole maize and theoretically greater competition for water, they were not more prone to yield loss with drought.

Pigeonpea + blackgram in 1:3 ratio recorded higher pigeonpea equivalent yield, net return and B:C ratio (12.25 q/ha, 35250/ha and 1.81 respectively) as compared to sole pigeonpea (4.90 q/ha, 12850/ha and 1.67, respectively) in Kalaburgi district NICRA village. Sole pigeonpea growth has been drastically reduced as a result of heavy rainfall (194.6) in October, which caused water stagnation in crop fields, resulting in a decreased crop yield but inter crop of pigeonpea + blackgram reduced the risk of that extreme weather condition. Kathmale *et al.,* (2014) reported that, the legumes as intercrops act as cover crops in wider row spaced pigeonpea resulting in higher *in-situ* moisture conservation and efficient utilization by both the component crops, further more helping in increased pigeonpea equivalent yields.

Under NICRA villages of Chikkadoddavadi Korategere taluk, Tumkuru, intercropping of finger millet + pigeonpea (8:1) recorded higher finger millet grain equivalent yield of 20.7 q/ha with higher net return (Rs.21457/ha and B:C ratio (1.85) than sole finger millet cropping system (20.1q/ha, Rs.20466/ ha and 1.83, respectively). This was attributed to the better performance of small millets even under more than 30 days dryspell and erratic rainfall during crop growth period, both as sole crop and intercrop probably due to their drought tolerance (Shashidhara *et al.,* 2000). Adikant *Pradhan et al.* (2014) and Santosh Nagappa Ningoji *et al.* (2021) reported that finger millet intercropping system recorded the better yield and monetary returns as compared to the solecrop.

TABLE 5

Performance goat shelter with raised platform in NICRA village Alappuzha district, Kerala

Intervention	Unit	Farmers (No.)	No. kid / year	Increase (%)	Net return (Rs./ha)	B:C
Goat shelter with raised platform	13	13	17	112.50	57345	1.7
Tradition goat shelter	4	4	8	-	4419	1.1

Goat Shelters with Raised Platforms

Heavy rains followed by an unprecedented flood caused devastating effects in all low-lying areas, with most livestock shelters submerged or destroyed. However, shelter management for small ruminants to tackle flood condition the construction of goat shelters with raised platforms helped to overcome this difficulty. Disease outbreak was reduced by following these practices and improved shelter, reducing the mortality from 40 per cent to 0. This resulted increased number of kids per year (17 kids/ year) with net return of Rs.57345 and B:C of 1.7 compared to traditional goat rearing shelter (8 kid/ year, Rs.4419 and 1.1, respectively) (Table 5). Ravi *et al*., (2022) stated that higher body weight gain was observed in the 6 month old male kids of Marwari breed, when reared under closed type improved animal shelter during summer months. Kids gained 9.52 kg body weight in improved shelter compared to 7.52 kg in traditional shelter during 6 months period of experiment from May to October.

Climate resilient technologies for aberrant rainfall situations play a crucial role in agriculture for sustaining the productivity and livelihood of farmers. Selection of variety according to the weather condition and finger millet + pigeonpea, groundnut + pigeonpea, pigeonpea + blackgram, maize + pigeonpea and greengram + pigeonpea inter cropping systems would enhance the productivity and economic benefits to the dryland farmers. Goat shelters with raised platforms aided in overcoming flood-related difficulties.

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