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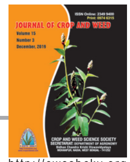

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Enhancing productivity through climate smart agriculture under changing weather of rainfed farming system

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ABSTRACT

In addressing climate change impacts on agriculture,numerous factors influence a particular location specific adoption of Climate Smart Agricultural technologies. A field experiment was conducted at S.G. College of Agriculture and Research Station, Jagdalpur during kharif 2015 to 2017 and the soil was sandy loam, low in organic carbon (0.43%), available N (178 kg/ha), available P (21.4 kg/ha) and medium in available K (179 kg/ha) showing acidic (pH 6.8) reaction. Experiment was conducted in randomized block design having seventeen treatments in four sets with three replications. Foliar spray @ 2% of nitrogen at the time of flower initiation enhanced the grain yield of rice up to2098 kg/ha in test variety MTU 1010, whereas test variety was MTU 1001produced 1870 kg/ha. Harvested rainwater used for life saving irrigation (2 cm depth) at tillering stage had higher grain yield (1503 kg/ha), net returns (Rs. 41463/ha), B:C ratio (3.16) and WUE (1.10 kg/ha-mm). On other hands, spray of soluble fertilizer (19:19:19 NPK) along with 0.5% $ZnSO_4$ on foliage recorded significantly more grain (2160 kg/ha) and straw yield(2480 kg/ha). Increasing rate of grain yield (6757 kg/ha), net returns (Rs. 57459/ha), B:C ratio (2.74) and RWUE (3.72 ka/ha-mm) was also found under transplanting of 20 days old seedlings. Scooping created digging out soil with spade in between inter rows of maize recorded more grain yield by 44.5% (1731 kg/ha) than that farmers' practice (930 kg/ha). Sowing Rice+Dhaincha (1:2) was another important contingent plan because crop sown with Dhaincha together using seed drill supported rice plant initially for growth and development.

Keywords: Climate Smart Agriculture, rainfed farming, mitigation strategies, offset weather

Climate Smart Agriculture (CSA) is a concept that guides actions required to transform and reorient existing agriculture systems effectively in ensuring food security on changing climate. CSA focuses to tackle three main prospective which includes sustainably increasing agriculture productivity and income, adapting and building resilience to climate change and at last reducing green house gas emission, where it is possible. Climate change is emerging threat on agriculture, food security and agriculture based livelihood of millions in many areas of the world (IPCC, 2014).Many studies indicate that agriculture production might be significantly influenced due to increase in temperature (Lobell *et al.*, 2012 and Aggarwal *et al.*, 2009), variation in rainfall patterns (Prasanna, 2014; Mall *et al.*, 2006) and uncertain frequency and intensity of extreme climatic events (Brida and Owiyo, 2013; Singh *et al.*, 2013). Broadly, CSA points out on resilient food production systems that lead to food and income surety under climate change and variability (Vermeulen *et al.*, 2012; Lipper *et al.*, 2014). CSA enforces sustainable development of agricultural systems through practices and approaches that can improve food security, resilience, and low emissions development with face of science link in to climate change (FAO, 2010).

Traditional to modern techniques are still being used among various groups of farmers, researchers and relevant people for tackling climate based agriculture which is common feature of rainfed farming. The technique of crop saving is very important during aberrant weather condition because of short and long change in weather affects from production. Generally weather deals with early season, mid season and late season dry spells which always opens the way to manage the irregularities of weather. Smart way of working is RTCP (Real Time Contingent Plan) and preparedness includes either before dry spell or manages while problem occurring, commonly soil manipulation and crop based approaches are adopted for managing aberrations of weather.

The average rainfall of the region is 1399 mm varying seasonal rainfall of 1118.6 mm during June - September. Abnormal and high intensity rainfall for short period is increasing during July-August (30, 32 and 34 Standard Meteorological Weeks) and October (41 and 44 Standard Meteorological Weeks). The area has also

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been experienced extreme events of hail storms, floods and cold waves (sometimes). There has been a considerable shift in the rainfall pattern and the quantum of rainfall during S-W monsoon (6%) and N-E monsoon (32%) has more during last ten years and sowing window of the major rainfed crops is delayed in 24^{th} to 25^{th}Standard Meteorological Weeks. The ground water table varies between 6 to 15 m based on topography with seasons. Generally, climate of the agro-climatic zone is defined as moist sub-humid and 80% of the total annual rainfall obtained by south-west monsoon in last 30 years which indicated that the variability in rainfall during S-W monsoon. Onset of monsoon is occurred near 24^{th}Standard Meteorological Weeks (SMW). Prasanna (2014) reported that the impacts of rainfall was more pronounced in rainfed farming.

During *kharif*, the onset of monsoon is generally in time rarely it is experienced delayed for 5-10 days. An average rainfall is of 1297 mm, sometimes it excesses by 300-500 mm compared to the normal. During S-W monsoon, there was 1408.5 mm rainfall which was 244.3 (21.8%) mm surplus compared to normal rainfall (1122 mm). N-E monsoon occurs during October- December received 235.9 mm which was more than 121.1 mm as that of normal (115.0 mm). In summer, 75.0 mm of rainfall was received which is deficit by 70.8 mm (48.5%) compared to normal rainfall of 146.1 mm. The marginal and small farmers were found more vulnerable in the region with the study of the past 15 years having 5 dry spells in September and 11 dry spell in October which were at panicle initiation and reproductive stages led to soil moisture deficit for major rainfed crops. The source of irrigation was farm ponds and well which was about 2% of cultivated area. With basic motto of NICRA on station trial and then up-scaling at farm level after evaluation is main aim of the project. Under NICRA, weather related abnormalities are addressed at regional level to combat extreme or awkward situations. Many studies have successfully used remote sensing with agricultural statistics in mapping agriculture (Erb*et al.*, 2007).

MATERIALS AND METHODS

Bastar plateau region is situated in southern most of Chhattisgarh, Dandkaranya and Eastern Ghats eco-sub-region (AESR 12.1) known as Moist Sub-humid zone (1250-1500 mm) and the Bastar plateau is sudden elevated portion of Chhattisgarh with annual normal rainfall is 1297 mm which extends the length of growing period upto 180-210 days.

A field experiment was conducted at S.G. College of Agriculture and Research Station, Jagdalpur during *kharif* 2015 and 2017. The soil was sandy loam, low in organic carbon (0.43%) available N (178 kg/ha), available P (21.4kg/ha) and medium in available K (179kg/ha) with acidic (pH 6.8) in reaction. Experiment was conducted in randomized block design having seventeen treatments in four sets with three replications.

The treatments comprised of 2% nitrogen spray which was prepared by diluting 9 g nitrogen in 450 litres/ha water for spraying at flowering and 500 litres/ha water was sprayed directly on standing crop at dry spell occurred along with check plot for mid season drought. Treatments for terminal drought, spraying of fertilizer 19:19:19 NPK 2% and $ZnSO_4$ @ 0.5% alone and in combination were applied. Dilution of 4.34 kg of urea into 200 litre water was done as stock solution for spraying on crop during dry spell when soil moisture went below 30% as available soil moisture, spraying was done with knapsack sprayer on standing crop uniformly.

For excess rainfall event, multi storey nursery was framed with locally available materials giving shape of tray size 1x3 m in 4 layers upright stands. Nursery was prepared at farm considering four storeys and staggered planting of 10, 15 and 20 days old seedlings which was planted on moist fields and simultaneously conventional nursery that was sown on flat ground for transplanting at 25 days old seedlings to avoid water logged condition on flat nursery during rainy days. During rainy season with staggered sowing of nursery and transplanting in prepared fields was done.

Preparedness for rainwater management, scooping between rows was done by running country plough at 2 metre interval, spaded out soil at 50 cm interval in running row, placing of FYM in row by seed drill @ 1.0 q/ha was also done.

Rice variety CR 40 was mixed with *Dhaincha* in 2:1 ratio and sown by seed cum fertilizer drill. Compartmental bunding of field at 20x20 m by embarking 6 cm high around the plot to impond water on rice crop along check plot and 20 days old seedlings were transplanted as conventional method and weedy cheek.

Preparedness

Scooping was done in between alternate rows by spading out soil of 3 inches at 50 cm interval to stop some water and enhancing infiltration in root zone for avoiding moisture stress. Furrow opening was done by running country plough in between alternate rows across the slope crop was sown to slow down rain water. Planting of FYM in furrow using seed cum fertilizer drill @ 100 kg/ha was done along seed sowing. FYM was finely crushed and sieved then weighed and the crushed FYM was poured into fertilizer groove to place prior to seeds in furrow. Rice+*Dhaincha* (1:2) were sown by seed cum fertilizer drill after mixing together as dry seeding, left for growing together upto 30 days and sprayed 1.0 kg/ha 2,4-D on standing crops to smothering *Dhaincha* to give growth up the rice crop.

Economical analysis was also done for each treatment. Data recorded under experiments was subjected to statistical analysis (Panse and Sukhatme, 1985). A net return, gross return and by Benefit: cost ratio for each treatment was also calculated. Pooled data of five years are presented in the Tables.

RESULTS AND DISCUSSION

A. Real time contingency planning

I. Mid season drought

In *kharif* season, a dry spell of 8 days was encountered with the flowering stage of rice during 24-31October in almost every year. The higher grain yield of 1860 kg/ha, net returns of Rs. 14941/ha, RWUE and B:C ratio were 1.83 kg/ha-mm and 2.47compared to farmers' practice *i.e.*, no spray (1024 kg/ha) was obtained with foliar spray of 2% nitrogen (Table1)

Table 1. Mitigation option for weather aberrations during cropping season

S. No.	Real time contingent plan	Grain yield (kg/ha)	% increase over control	RWUE (kg/ha-mm)	Net Return (Rs.)	B:C
1	**Mid season drought**					
a	Spray 2% nitrogen at flowering	1860	55.04	1.83	14941	2.47
b	Spray water @ 500 litre per ha	1342	76.27	1.49	12147	2.01
c	Control (No spray)	1024	0.00	1.21	9876	1.04
	SEm±	**178**	**-**	**0.11**	**933**	**0.15**
	CD (P=0.05)	**528**	**-**	**0.36**	**2796**	**0.47**

Table 2.Real time contingent plan for terminal drought

S. No.	Real time contingent plan	Grain yield (kg/ha)	% increase over control	RWUE (kg/ha-mm)	Net Return (Rs.)	B:C
a	19:19:19 @ 0.5% NPK	2120	58.38	2.01	11272	2.45
b	19:19:19 @ 0.5% + ZnSO4 @ 0.5%	2160	57.29	2.09	12430	2.54
c	ZnSO4 @ 0.5%	1580	78.33	1.45	6784	1.94
d	Control (No spray)	1238	0.00	0.83	3234	0.45
	SEm ±	**15**	**7.02**	**0.02**	**398**	**3.01**
	CD (P=0.05)	**46**	**22.01**	**0.08**	**1160**	**0.10**

II. Terminal drought

Terminal drought was encountered in *kharif* 2017;a dry spell of 30 days (1-30 November) coincided at grain formation and maturity stage of rice. Foliar spray resulted significantly 170 kg/ha higher grain yield during the moisture stress condition than sprays after relieving stress (1340 kg/ha). Comparatively, foliar spray of water soluble fertilizer (19:19:19 NPK) with 0.5% $ZnSO_4$ recorded significantly more grain as well as straw yield of 2160 and 2480 kg/ha, respectively, net returns (Rs. 12430/ha), B:C ratio of 2.54 and RWUE attained 2.09 kg/ha-mm than rest of treatments (Table2). Similar finding was quoted by Gathala *et al.* (2011). Nitrogen management was more apparent in field condition which influenced more with stipulated time period (Bhavsar, 2003; Pravallika *et al*., 2020).

III. Excess rainfall event

Heavy rainfall exceeded by 61.2% in June 2017 than normal rainfall (235 mm) vitiated rice nursery due to inundation of rain water and this type of situation was commonly happened with field condition (Brida and Owiyo, 2013). Under such situation, the multi-storied nursery raising technique was taken in considering 10, 15, 20 and 25 days old seedlings of rice (var.-MTU 1010) transplanted by synchronized seeding age with rainfall breaks. The higher grain yield (6757 kg/ha), net returns (Rs. 57459/ha), B:C ratio (2.74) and RWUE (3.72 ka/ha-mm) was recorded when transplanted 20 days old seedlings but yield was increased more than 200% with transplanting 15 days old seedlings (Table 3). Small land holders were highly influenced by excess rain and most of marginal and small farmers dwelling under such the circumstances in the region due to sudden down pour as similar studies was finalized by Balew *et al*. (2014).

Table 3:Real time contingent plan for Excess rainfall event during July-August

S. No.	Real time contingent plan	Grain yield (kg/ha)	% increase over control	RWUE (kg/ha-mm)	Net Return (Rs.)	B:C
a	Multi-storey nursery 10 days old	3733	162.01	3.35	21169	2.79
b	Multi-storey nursery 15 days old	3009	201.00	3.18	36479	2.40
c	Multi-storey nursery 20 days old	6757	89.51	3.72	57459	2.74
d	Conventional nursery 25 days old	6048	0.00	3.76	48954	1.70
	SEm±	**236**	**13.45**	**0.14**	**2830**	**0.13**
	CD (P=0.05)	**710**	**38.99**	**0.42**	**8505**	**0.41**

Table 4.Preparedness for rainwater management

S. No.	Real time contingent plan	Grain yield (kg/ha)	% increase over control	RWUE (kg/ha-mm)	Net Return (Rs.)	B:C
a	Scooping between row	1563	88.79	3.67	36091	3.02
b	Furrow opening at 1 m interval	1876	73.97	5.00	58818	3.36
c	Placing FYM in row @ 1.0 q/ha	1785	77.74	5.29	45056	3.51
d	Sowing Rice+*Dhaincha* (1:2)	1923	72.18	5.58	51293	2.81
e	Compartmentation of 20x20m	1861	74.58	5.87	97531	2.72
f	Control (No implementation)	1388	0.00	6.16	50376	1.42
SEm+_		**21**	**3.68**	**0.09**	**-**	**0.45**
CD (P=0.05)		**63**	**11.06**	**0.30**	**-**	**0.16**

Table 5: List of respondent, adoption and reception on real time contingent plan

S. No.	Real time contingent plan	Respondent	Adoption	Repetition
1	Spray 2% nitrogen at flowering	154	121	43
2	Spray water @ 50 litre per ha	111	87	31
3	Control (No spray)	85	67	24
4	19:19:19 @ 0.5% NPK	176	138	49
5	19:19:19 @ 0.5% + ZnSO4 @ 0.5%	179	141	50
6	ZnSO4 @ 0.5%	131	103	36
7	Control (No spray)	103	81	29
8	Multi-storey nursery 10 days old	309	243	86
9	Multi-storey nursery 15 days old	559	440	156
10	Multi-storey nursery 20 days old	501	394	140
11	Conventional nursery 25 days old	249	196	69
12	Scooping between row	129	102	36
13	Furrow opening at 1 m interval	155	122	43
14	Placing FYM in row @ 1.0 q/ha	148	116	41
15	Sowing Rice+*Dhaincha* (1:2)	159	125	44
16	Compartmentation of 20x20m	154	121	43
17	Control (No implementation)	115	90	32
	Total	**3417**	**2686**	**952**

B. Preparedness

I. Rainwater management

Scooping by spading out soil for inter rows of maize which increased the grain yield by 44.5% (1731 kg/ha) than that farmers' practice (930 kg/ha) reflecting higher net returns (Rs. 6346.80/ha), B:C ratio (1.15) and RWUE (2.06 kg/ha-mm) (Table 4). Rainwater management might be effective ways for harnessing bumper crops if rain water is properly harvested and managed under rainfed condition of regions (Claessens *et al*., 2012; Singh *et al.,* 2013). Mall *et al.* (2006) explained that the rainwater is crucial for enhancing water use under rainfed farming in which crops are grown with vagaries of rainfall. Respondents of the villages for contingent plan mostly depends on adoption then their repetition of the technologies demonstrated after validation under NICRA trials; among the real time contingent plans, Multi-storey nursery 15 days old was more (501) widely adopted by farmers with maximum replications due to heavy shower with onset which vitiates the nursery of rice led to escape from such loss followed by Multi-storey nursery 20 days old.

Sowing Rice+*Dhaincha* (1:2) was another important contingent plan because crop was sown with *Dhaincha* together using seed drill which supported rice plant initially for growth and development. To avoid moisture stress of rice, 19:19:19 @ 0.5% NPK alone and with combination of $ZnSO_4$ @ 0.5% gave higher yield that is why 179 farmers used and still 49 farmers used the technology as they faced the adverse weather condition under rainfed ecosystem (Table 5).

CONCLUSION

In climate change scenario, foliar spray of nitrogen @ 2% at flower initiation, life saving irrigation (2 cm) from harvested rainwater provided at tillering stage and again another spray of soluble fertilizer (19:19:19 NPK) along with 0.5% $ZnSO_4$ on foliage recorded significantly more grain (2160 kg/ha) and straw yield (2480 kg/ha). Higher grain yield (6757 kg/ha), B:C ratio (2.74), net returns (Rs. 57459/ha) and RWUE (3.72 ka/ha-mm) were found with 20 days old seedlings under sudden down pour and no time of nursery preparation for specially to marginal and small farmers. Scooping by spading out soil in between inter rows of maize adverse climate avoiding approach increased the grain yield by 44.5% than that farmers' practice. Sowing Rice+*Dhaincha* (1:2) was another important contingent plan for enhancing root zone moisture because crop and *Dhaincha* were sown together using seed drill which supported rice plant initially under short dry spells.

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