AATCC Review

02 April 2023: Received
24 July 2023: Revised
26 September 2023: Accepted
29 November 2023: Available Online

www.aatcc.peerjournals.net

Research Article

Open Access

Impact of Climate Resilient Agriculture Practices: An experience from the marginal farmers of Bihar

Sripriya Das[1]*, Sunita Kushwah[2], Prem Prakash Gautam[3], Kumari Namrata[3], Kavita Verma[3], Swapnil Bharti[3], Anup Kumar Singh[3], Abhik Patra[4], Madhu Sudan Kundu[5], Raj Kumar Jat[6]

[1]Subject Matter Specialist (Crop Production), Krishi Vigyan Kendra, Vaishali, RPCAU, Vaishali, Bihar, 844102 India.
[2]Krishi Vigyan Kendra, Vaishali, RPCAU, Pusa, Vaishali, Bihar, 844102, India.
[3]Subject Matter Specialist, Krishi Vigyan Kendra, Vaishali, RPCAU, Vaishali, Bihar, 844102 India.
[4]Subject Matter Specialist, Krishi Vigyan Kendra, Narkatiaganj, West Champaran, Bihar, 845455- India.
[5]DRPCAU, Pusa, Samastipur, Bihar, 848125- India.
[6]BISA, Pusa, Samastipur, Bihar, -848125- India.

ABSTRACT

Climate-resilient agriculture (CRA) is an approach that includes sustainable use of existing natural resources through crop and livestock production systems and achieve long-term higher productivity and farm income even under climate variabilities. The Climate Resilient Agriculture (CRA) programme was conducted by Krishi Vigyan Kendra, Vaishali in five villages of Bihar, India. A survey conducted revealed that after the introduction and three years of continuation of the programme, maximum number of respondents (58.88%) were found to be in the category of higher adoption for CRA technologies due to the assured benefits in economic terms as well as for soil conservation and environmental protection and has made more and more farmers to adopt those technologies. Demonstrations were conducted in 595 acres in kharif season and 623 acres in rabi season. The B:C ratio of all kharif crops were higher with CRA technology application (2.51 for paddy, 2.52 for maize. 1.58 for pearl millet and 1.28 for sorghum) as compared to conventional practices (1.92 for paddy, 2.11 for maize. 1.25 for pearl millet and 1.10 for sorghum). Crops demonstrated in rabi season also showed that both the yield and B:C ratio (2.23 for wheat, 3.5 for lentil, 2.9 for chickpea, 2.13 for mustard and 2.2 for rabi maize) were higher with the application of CRA technologies as compared to traditional ones (1.8 for wheat, 2.5 for lentil, 1.3 for chickpea, 1.73 for mustard and 1.68 for rabi maize). This programme has open many new climate resilient options for the farmers to adopt in this scenario of changing climatic conditions. The climate resilient agriculture (CRA) technologies have been very successful especially in rabi crops and increases the net profit of farmers by cutting down the cost of cultivation. However, the major challenges faced in the implementation of the programme was to convince farmers to come out from their traditional method of crop cultivation and adopt our technologies in the initial stages which were later reduced when the results started showing the impact.

Keywords: *Climate Resilient Agriculture, conventional practices, climatic conditions, soil conservation, environmental protection, cost of cultivation, natural resources, climate variabilities.*

INTRODUCTION

Climate change is considered as one of the major environmental problems of present century which includes change in average weather conditions and occurrence of extreme weather events as well. This may be due to natural internal processes or persistent anthropogenic activities *viz.* increased industrial emissions, fossil fuel combustion, deforestation, biomass burning, change in land use and land management practices etc. which have resulted in an increased emission of harmful green houses gases (CO_2, CH_4, N_2O) into the atmosphere. These gases increase the temperature of the earth surface causing global warming which in turn leads to regional changes in climate related parameters such as rainfall, soil moisture, sea level etc. The extensive and frequent occurrence of extreme climatic events such as heat, droughts and floods in many parts of the world including India may be due to global warming. Climate change and agriculture are interconnected processes and agriculture is particularly vulnerable to climate change especially in a country like India where more than 70% of the farmers belong to small and marginal category as most of the agricultural activities are practices correlating with required climatic events. Higher temperature may lead to yield reduction in many crops by encouraging weed and pest proliferation. Change in precipitation pattern may hamper timely agricultural operations leading to short term crop failure and long term yield falloffs. Thus, it is high time to move to alternate Climate Resilient Agriculture (CRA) practices to cope up with the continuing and upcoming negative effects of climate change. Climate-resilient agriculture (CRA) is an approach that includes sustainable use of existing natural resources through crop and livestock production systems to achieve long-term higher productivity and farm income even under climate variabilities. Climate Resilient agriculture practices including improved access and utilisation of technologies and mechanisation, increased use of resource conservation technologies, adoption of climate resilient crops and varieties, tend to reduce hunger

Corresponding Author: **Sripriya Das*
*Email Address: **sripriyadaspaul@gmail.com***

DOI: https://doi.org/10.58321/AATCCReview.2023.11.04.415

and poverty in the face of climate change for forthcoming generations. CRA practices have the capability to alter the current situation and sustain agricultural production from the local to the global level in a sustainable manner. Climate-resilient agriculture safeguards food security by enhancing smallholder farmers' productivity and transforms the current system to withstand current and future climate change effects [5]. Adoption of early maturing and drought tolerant varieties of certain crops, inclusion of nutri-cereals such as pearl millet, finger millet, foxtail millet etc in cropping system, cultivation of green manuring crops such as dhaincha, cowpea, green gram etc, direct sowing of crops using zero tillage machine and bed planters, intercropping, rain water harvesting and laser land levelling of entire field are some of the CRA technologies that can have beneficial effects in terms of net return and environmental friendliness as well.

The Climate Resilient Agriculture (CRA) programme has been formulated to prepare a workplan for the state of Bihar to cope up with current and future climate risk. The Borlaug Institute for South Asia (BISA) is the Nodal organisation along with Bihar Agricultural University (BAU), Sabaur, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Samastipur, ICAR-RCER, Patna are the partner for implementation of the project.

MATERIALS AND METHODS

The Climate Resilient Agriculture (CRA) programme was conducted by Krishi Vigyan Kendra, Vaishali in five villages namely Nirpur, Bardiha, Bajitpur, Rasalpur and Repura of Patepur block with the technical support of Borlaug Institute for South Asia (BISA), Pusa. The demonstrations were being conducted in 595 acres in *kharif* season, 623 acres in *rabi* season and 350 acres in summer season each year starting from the year (2020-21). All the demonstration plots were levelled using laser land leveller machine and sowing was done using machines such as happy seeder, zero tillage machine, drum seeder and raised bed planter. Recommended dose of fertilisers and plant protection measures was applied in the demonstrated plots.

A survey was conducted during the year 2022-23 at 5 CRA villages (Nirpur, Bardiha, Bajitpur, Rasalpur and Repura) with 100 respondents to study the adoption level of farmer for different CRA technologies demonstrated at farmers field through the implementation of CRA programme. Personal interviews were conducted using a pretested structured interview schedule. The responses received were coded, processed and tabulated.

In *kharif* (2022-23), paddy was demonstrated in 535 acres land (including alternate wetting drying (AWD) in 56 acres, direct seeded rice (DSR) in 399 acres and drum seeding in 80 acres), maize was demonstrated in 15 acres with raised bed technology, pearl millet was demonstrated in 3 acres with raised bed technology and sorghum was demonstrated in 8 acres with raised bed technology as well. Rest area was covered under other kharif crops with different CRA technologies. In *rabi* (2021-22), wheat was demonstrated in 490 acres land including zero tillage in 480 acres and double row raised bed planting in 10 acres, lentil was demonstrated in 20 acres with zero tillage, chickpea was demonstrated in 18 acres with zero tillage, mustard was demonstrated in 105 acres with raised bed technology and maize was demonstrated in 4 acres with raised bed technology. The grain yield (q/ha) and straw yield (q/ha) was recorded from each demonstration plot by crop cutting experiment. Statistical analysis was done to compare the significant difference of grain yield and straw yield obtained before and after the implementation of the programme in which t-test was used where the number of demonstrations (N) was less than 30 and z-test was used where the number of demonstrations (N) was more than 30. The following formula was used for t-test and z-test as described in [4].

$$t= \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}},\ z= \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}}}$$

RESULTS AND DISCUSSION

Distribution of respondents according to their adoption of different CRA technologies introduced under the CRA Programme has been presented in Table 1. It indicates that in case of Laser Land levelling, majority of the people (68%) have already adopted and others are willing to adopt this technology which was only 8% in the category of high adoption before the programme. The adoption was 17% (before)and 27% (after) in medium category and 75% (before) and 5% (after) in lower category under the same CRA technology. This is because farmers across the village have seen the positive effects of land levelling in resource conservation and input saving after about 3 years of implementation of the programme. [2] also reported that laser land levelling saves 15-30% water under various crops and cropping patterns, improves operational efficiency i.e., reduces operating time by 10 - 15% leading to reduced consumption of seeds, fertilizers, chemicals and fuel.

There has been an increase in percentage (i.e. 8%) in the category of higher adoption and decrease in percentage (i.e. 6%) in the category of lower adoption after the implementation of programme as compare to before in cultivation of green manure crops as through different activities of the programme, efforts were taken to increase awareness among the farmers about the importance of cultivation of green manure crops instead of keeping the land fallow after wheat. According to the findings of [8][11][12], green manuring improves soil organic matter, soil structure and also increases soil nitrogen content.

Frequency of adoption of direct sowing of crops in lines in higher adoption category has increased from 4% to 80% and has decreased in both medium category and lower adoption category from 13% to 85 and 83% to 12%, respectively after many demonstration were laid down with the use of this technology under CRA programme indicating that farmers are extremely moved with the bumper results of direct line sowing as compared to conventional broadcasting methods.

Similar findings were recorded in case of zero tillage where the adoption in the category of higher adopters were even higher (82%) after the introduction of the programme as compared to only 4% before the programme. The adoption was 36% (before)and 6% (after) in medium category and 56% (before) and 12% (after) in lower category for the same climate resilient technology.

From table 1, increase in higher adoption levels and medium adoption levels by 22% and32%, respectively and decrease in lower adoption level by 54% was observed in the case of raised bed technology attributing to higher yield and resource saving for certain crops. Similar findings were also reported by [6].

Table 1 indicated that earlier majority of the people belonged to lower category of adoption (88%) for including pulse in cropping system and only 5% belonged to medium category and 7% belonged to higher categories of adoption. However, this percentage went upto 50% in the category of higher adoption, 36% in the category of medium adoption and 14% in the category of lower adoption after three years of continuation of the programme when the farmers were made aware about the importance and demand of pulse cultivation through different programmes organized under the programme.

Inclusion of millets in the existing cropping system of farmers was a major task that was taken up through the introduction and implementation of CRA programme. Earlier, the percentage was highest in lower adoption category (95%) followed by only 5% of higher adoption. However, after millets were introduced in demonstration plots under programme and farmers were made aware of, the percentage increased to 22% in the higher adoption category and 48% in middle adoption category with a decrease in percentage to 30% in the lower adoption category. This is probably because of the fact that millets being climate resilient and hardy crop has stand out well and given stable yield even after extreme climatic events such as flood and less rainfall that occurred during 2021 and 2022, respectively. [9] also reported that millets are known for their climate-resilient features including adaptation to a wide range of ecological conditions, less irrigational requirements, better growth and productivity in low nutrient input conditions, less reliance on synthetic fertilizers, and minimum vulnerability to environmental stresses.

The percentage in category of higher adoption has increased from 35% to 65% , in the medium category, the percentage got decreased from 33% to 28% and in the lower adoption category, it got decreased from 32% to 7%, as well after the increase in awareness about the type of crops to be chosen, distance to be maintained and other package of practices required for intercropping. Also as documented by [10], intercropping increases production due to the complementary effects of intercrops on each other and reduced competition between them.

The percentage of adoption in higher category, middle category and lower category was 8%, 23% and 69%, respectively before the programme was started in the studied villages in case of use of tractor mounted machines for spraying agro-chemicals. However, after the implementation of the programme , the percentage in higher, medium and lower category was 78%, 16% and 6% respectively indicating that when farmers came to know about the existance of such machinery through CRA programme which was earlier unknown and unavailable to them, the adoption rates of such machines automatically increased considering lower labour requirement and fastness in operation.

Thus, from the above discussion it can be concluded that the introduction and implementation of CRA Programme in villages of Patepur block in the Vaishali district of Bihar has increased the adoption level of CRA technologies in the higher adoption category and decreased the same in the lower adoption categories indicating that CRA technologies have proved to show assured benefits both monetary as well as environmental terms which has made more and more farmers to adopt those technologies after three continuous years of running the programme.

Table 1. Distribution of respondents according to their adoption of climate resilient agriculture (CRA) technologies (N=100).

S.No.	Climate Resilient Agriculture (CRA) technologies	Categories of adoption	Frequency	
			Before introduction of Programme	After introduction of Programme
1.	Laser Land Levelling	L	75 (75%)	5 (5%)
		M	17 (17%)	27 (27%)
		H	08 (8%)	68 (68%)
2.	Cultivation of green manure crops	L	16 (16%)	10 (10%)
		M	47 (47%)	45 (45%)
		H	37 (37%)	45 (45%)
3.	Direct seeding (In lines)	L	83 (83%)	12 (12%)
		M	13 (13%)	08 (8%)
		H	04 (4%)	80 (80%)
4.	Zero tillage	L	56 (56%)	12 (12%)
		M	36 (36%)	06 (6%)
		H	08 (8%)	82 (82%)
5.	Raised Bed Technology	L	74 (74%)	20 (20%)
		M	08 (8%)	40 (40%)
		H	18 (18%)	40 (40%)
6.	Inclusion of pulses in cropping system	L	88 (88%)	14 (14%)
		M	05 (5%)	36 (36%)
		H	07 (7%)	50 (50%)
7.	Inclusion of millets in cropping system	L	95 (95%)	30 (30%)
		M	00 (0%)	48 (48%)
		H	05 (5%)	22 (22%)
8.	Intercropping	L	32 (32%)	07 (7%)
		M	33 (33%)	28 (28%)
		H	35 (35%)	65 (65%)
9.	Use of tractor mounted machines for spraying of agro-chemicals	L	69 (69%)	06 (6%)
		M	23 (23%)	16 (16%)
		H	08 (8%)	78 (78%)

Table 2 depicting distribution of respondents according to their overall extent of adoption of climate resilient agriculture (CRA) technologies indicates that before the CRA programme was started in the villages of Patepur block, maximum number of respondents viz. 65.3% belonged to category of lower adoption followed by medium (20.26%) adoption category and only 14.44% of the respondents belong to higher adoption category. However, after the introduction and three years of continuation of the programme, maximum number of respondents (58.88%) are found to be in the category of higher adoption followed by medium adoption (28.22%) and lower adoption (12.90%). Thus, it can further be concluded that the programme has open many new climate resilient options for the farmers to adopt in this scenario of changing climatic conditions and adoption has certainly increased for the mentioned CRA technologies that has been demonstrated in farmer's field under this programme.

Table 2. Distribution of respondents according to their overall extent of adoption of climate resilient agriculture (CRA) technologies among the farmers (N=100)

S. No.	Categories	Frequency	
		Before introduction of programme	After introduction of programme
1.	Low	65.3 (65.30%)	12.90 (12.90%)
2.	Medium	20.26 (20.26%)	28.22 (28.22%)
3.	High	14.44 (14.44%)	58.88 (58.88%)
		100 (100%)	**100 (100%)**

The t values and z values (“t” value in case N<30, “z” value in case N>30) for grain yield and straw yield before and after the implementation of CRA technologies in kharif season are present in Table 3. It is evident from Table 3 that z-test was found to be non-significant in case of both grain yield and straw yield for paddy sown with all three CRA technologies *viz.* alternate wetting and drying (AWD), direct seeded rice (DSR) and drum seeding. However, in case of B:C ratio, it was found to be higher for all three CRA technologies of rice as compared to conventional rice cultivation method. Alternate wetting and drying (AWD) technology of rice recorded a B:C ratio of 2.20, direct seeded rice (DSR) recorded 2.51 and drum seeding recorded 2.44 which was higher when compared to the B:C ratio of rice before the implementation of CRA technologies (1.92) indicating that although significant differences were not obtained for yield (grain and straw) but the profit earned by the practicing farmers was evidently high in case of CRA technologies. It was certainly because of the low input requirement in terms of irrigation and labour that has significantly cut short the cost of cultivation and increased the profit. [3] also reported that DSR is more cost effective as compared to transplanted rice due to higher water productivity by >25% and labour saving by 13-37%.

Similar kinds of results were obtained for maize, pearl millet and sorghum sown on beds using tractor mounted bed transplanter. The t-test for grain yield and straw yield of raised bed maize and raised bed pearlmillet was found to be non-significantly higher. However the B:C ratio for raised bed maize (2.52) was found to be higher as compared to maize sown manually (2.11) before the programme was introduced. Also, bed planted pearl millet recoded greater B:C ratio of 1.55 as compared to the B:C ratio of 1.25 of the pearl millet cultivated by traditional method. In case of sorghum, maximum farmers used to cultivate this crop as fodder through ratooning, thus the straw yield of sorghum shown in Table 3 before the implementation of the programme is much higher than after. However, when the crop was grown for both grain and as well as straw without ratooning, the B:C ratio was found to be increased from 1.10 to 1.28 indicating growing profits to farmers with the adoption of this particular CRA technology (raised bed planting).

Table 3. Difference in production levels of before *(with conventional method of cultivation)* ***and after*** *(with Climate Resilient Agriculture (CRA) technologies)* ***the implementation of climate resilient agriculture (CRA) technologies in kharif crops***

S.No.	Crop and technology used	Mean production levels (q/ha)				“t” value and “z” value of mean differences		B:C Ratio	
		Grain yield (q/ha)		Straw yield (q/ha)					
		Before	After	Before	After	Grain yield	Straw yield	Before	After
1.	Paddy (AWD)	42.90	43.55	51.85	60.00	0.89*	1.52*	1.92	2.20
2.	Paddy (DSR)	42.90	47.85	51.85	58.66	1.12*	1.45*	1.92	2.51
3.	Paddy (Drum Seeding)	42.90	45.75	51.85	60.00	1.02*	1.52*	1.92	2.44
4.	Maize (Raised Bed)	40.00	49.52	95.00	102.00	1.76*	1.78*	2.11	2.52
5.	Pearl millet (Raised Bed)	16.50	22.00	35.00	45.28	2.15*	2.32*	1.25	1.55
6.	Sorghum (Raised Bed)	8.00	12.26	400-500	36.00	1.71*	-	1.10	1.28

***Significant at 0.05% level, *Non significant at 0.05% level*
“t” value in case N<30, “z” value in case N>30

Table 4 depicts the t values and z value for grain yield and straw yield of rabi season crops along with B:C ration for before and after the use of CRA technologies in those crops. In case of wheat crop, both the climate resilient technologies viz. zero tillage and raised bed planting showed significantly better results as compared to conventionally grown wheat crop. Grain yield and straw yield obtained from wheat crop sown under zero tillage (58.2 q/ha and 87.3 q/ha, respectively) was significantly higher compared to conventional wheat (37.3 q/ha and 55.95 q/ha, respectively) with a z value of 7.68 for grain yield and 9.02 for straw yield. Also, the B:C ratio was higher for this zero tillage (2.23) than conventional method (1.8). These findings are in accordance with the findings of [13] who also reported that after the adoption of zero tillage, the wheat yield was increased in many parts of the country.

Table 4. Difference in production levels of before** (with conventional method of cultivation) **and after** (with Climate Resilient Agriculture (CRA) technologies) **the implementation of climate resilient agriculture (CRA) technologies in rabi crops

S. No.	Crop and technology used	Mean production levels (q/ha)				"t" value and "z" value of mean differences		B:C Ratio	
		Grain yield (q/ha)		Straw yield (q/ha)					
		Before	After	Before	After	Grain yield	Straw yield	Before	After
1.	Wheat (Zero tillage)	37.3	58.2	55.95	87.3	7.68**	9.02**	1.8	2.23
2.	Wheat (Raised Bed)	37.3	60.50	55.95	90.75	8.59**	9.25**	1.8	2.17
3.	Lentil (Zero Tillage)	13.2	16.80	14.52	18.48	1.52*	1.53*	2.5	3.5
4.	Chickpea (Zero Tillage)	8.23	11.00	9.05	12.32	1.45*	1.48*	1.3	2.9
5.	Mustard (Raised Bed)	11.50	13.75	13.8	16.5	0.98*	1.01*	1.73	2.13
6.	Maize (Raised Bed)	86.00	100.00	54.00	75.00	5.42**	8.17**	1.68	2.20

***Significant at 0.05% level, *non-significant at 0.05% level*
"t" value in case N<30, "z" value in case N>30

Also, it is evident from Table 4 that the grain yield and straw yield recorded with raised bed technology of wheat crop (60.5 q/ha and 90.75 q/ha, respectively) was significantly higher as compared to conventional wheat (37.3 q/ha and 55.95 q/ha, respectively) with a z value of 8.59 for grain yield and 9.25 for straw yield. The B:C ratio recorded for raised bed wheat (2.17) was also higher than the traditional method of wheat cultivation (1.8). [3] also found that in studies carried out in India in rice-wheat system, the cost of production was significantly higher for conventional tillage in wheat as compared to zero tillage.

Similar trend was observed in case of maize sown with raised bed planter which recorded a significantly higher grain yield of 86 q/ha and straw yield of 100 q/ha as compared to manually sown maize with a grain yield of 54 q/ha and straw yield of 75 q/ha. This technology recorded a t value of 5.42 for grain yield and 8.17 for straw yield. Also, B:C ratio was higher for machine planted maize (2.20) as compared to manual planting (1.68). [1] also recorded 5-10% increase in maize yield with tractor drawn raised bed planter over conventional practice.

However, for other rabi crops such as lentil, chickpea and mustard, the grain yield and straw yield obtained with CRA technologies were not significantly higher than the conventional cultivation method of those crops but the B:C ratio was higher in each case. Zero tilled lentil recorded a higher B:C ratio of 3.5, zero tilled chickpea recorded a higher B:C ratio of 2.9 and raised bed mustard also recorded a higher B:C ratio of 2.13 as compared to the B:C ratios of their conventional cultivation methods (2.5, 1.3 and 1.73, respectively) indicating growing net return of farmers with the use of climate resilient technologies.

It can be concluded from the above discussion that in case of rabi crops, the climate resilient agriculture (CRA) technologies have been very successful and thus there is more adoption of those technologies among the practicing farmers.

Table 5. Mean yield and B:C ratio of crops introduced in CRA villages through the implementation of Climate Resilient Agriculture (CRA) Programme

S.No.	Crop	CRA Technology	Grain yield (q/ha)	Straw yield (q/ha)	Net Return	B:C Ratio
1.	Soyabean	Raised Bed	17.32	30.46	26123	2.07
2.	Groundnut	Raised Bed	18.42	35.66	17375	1.75
3.	Pigeon Pea	Raised Bed	12.65	37.50	29500	2.45
4.	Foxtail millet	Line sowing	9.60	25.5	12456	1.63

Table 5 indicates certain other crops such as soyabean, groundnut, pigeon pea and foxtail millet that were introduced in the villages of Patepur block of Vaishali district of Bihar under the climate resilient agriculture (CRA) Programme and grown using different CRA technologies. The results indicated that these crops when cultivated with CRA methods recorded good yield and profitable B:C ratio in the existing climatic and soil conditions. Soyabean recorded a B:C ratio of 2.07, groundnut recorded a B:C ratio of 1.75, pigeon pea recorded a B:C ratio of 2.45 and foxtail millet recorded a B:C ratio of 1.63 indicating that these crops can be included in the cropping system as climate resilient crops that would enrich the cropping system as well soil being leguminous and resilient millet crops.

Constraints in adoption of technology

The most important constraint in the adoption of Climate Resilient Agriculture (CRA) technologies as found from the conducted survey is fragmented land holdings of farmers. Majority of the farmers belonged to small and marginal category and had fragmented lands which is a major problem for the operation/ working of machines. Also availability of the machines at proper time and at proper rates is another problem. Apart from these, social factors like mindset of the farmers is also a major ice to break for the technologies to undergo wide adoption.

CONCLUSION

The above study showed that the introduction and implementation of CRA programme has increased the adoption level of CRA technologies among the farming community due to the assured benefits in both monetary as well as environmental terms and has made more and more farmers to adopt those technologies. This programme has open many new climate resilient options for the farmers to adopt in this scenario of changing climatic conditions.

The climate resilient agriculture (CRA) technologies have been very successful especially in rabi crops and increases the net profit of farmers by cutting down the cost of cultivation.

FUTURE SCOPE OF THE STUDY

Climate change is possibly the most intricate and challenging concern in today scenario, thus research aimed at mitigating the impacts of climate change in a country like India is very important in the present situation and will continue to be so in the future. Development and inclusion of region-specific climate resilient varieties in the cropping system can be a component of future focus in this type of studies.

ACKNOWLEDGEMENT

The authors of the paper extent their heartful gratitude to the Borloug Institute for South Asia (BISA), Pusa Bihar for their technical support and financial support.

REFERENCES

1. Dixit, J., Khan, J.N. and Kumar, R. 2017. Maize Mechanization for Hill Agriculture to Enhance Productivity. SKUAST J. Res., 19(1): 83-91.

2. Eid, A.R., Mohamed, M.H., Pipars, S.K., Bakry, B.A. 2014. Impact of laser land leveling on water productivity of wheat under deficit irrigation condations. Curr. Res. Agric. Sci., 2: 53-64.

3. Erenstein, O. and Laxmi, V. 2008. Zero tillage impacts in India's rice–wheat systems: A review. Soil and Tillage Res., 100:1–14.

4. Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research, John Wiley& Sons.

5. Gugissa, D.A., Abro, Z., Tefera, T. 2022. Achieving a Climate-Change Resilient Farming System through Push–Pull Technology: Evidence from Maize Farming Systems in Ethiopia. Sustainability, 14, 2648.

6. Hashimi, S.M., Sarhadi, W.A. and Afsana, N. 2021. Study of Raised Bed Planting Method on Yield Components of Wheat in Kabul. Int. J. Sci. Res., 10(1): 303-308.

7. Kaur, J. and Singh, A. Direct Seeded Rice: Prospects, Problems/Constraints and Researchable Issues in India. Curr Agri Res 2017;5(1). doi: http://dx.doi.org/10.12944/CARJ.5.1.03.

8. Kodaş, R., Er, C. 2012. Tahıllarda organik yetiştiricilik. Uludağ Üniversitesi Ziraat Fakültesi Dergisi, 26(1):103-116.

9. Kole, C., Muthamilarasan, M., Henry, R., Edwards, D., Sharma, R., Abberton, M. 2015. Application of genomics-assisted breeding for generation of climate resilient crops: progress and prospects. Front. Plant Sci. 6:563.

10. Mahapatra, S.C.2011. Study of grass-legume intercropping system in terms of competition indices and monetary advantage index under acid lateritic soil of India. AM. J. Exp., 1(1): 1-6.

11. Rosenfeld,A and Rayns, F.2011. Sort Out Your Soil - A Practical Guide to Green Manures. UK: COTSWOLD Grass Seeds Direct.

12. Talgre, L. 2013. Biomass Production of Different Green Manure Crops and Their Effect on The Succeeding Crops Yield. PhD Thesis. Tartu: Estonian University.

13. Veettil, R.C. and Krishna, V.V. 2013. Productivity and Efficiency Impacts of Zero Tillage Wheat in Northwest Indo-Gangetic Plains, Institute of Economic Growth, New Delhi, Working Paper No. 321: 1-29.

