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Influence of Climate Resilient Technologies in Blackgram Productivity and Its Adoption in Low Rainfall Areas of Karaipottanar Sub Basin in Tiruchirapalli District in Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climate change has emerged as one of the major global environmental issues that greatly influence agricultural production and food security. To meet these emerging challenges of climate change, there is an urgent need for developing promising improved technologies for mitigating of combating

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the adverse effect of climate change. Climate changes have a direct impact on rainfed crops including pulses. Reduction in yields due to climate change is prominent, since pulses occupy major area in rainfed situation. Hence the present investigation was carried out to study the impact of climate change on productivity of rainfed pulse and climate resilient technologies in increasing productivity of blackgram under rainfed situation. Mohanur block was purposively selected from Namakkal district of Tamil Nadu for the present study. Demonstrations were conducted in 50 farmer's field in 3 villages, where climate resilient technologies viz., improved blackgram variety VBN 8, *biofertilizer* application, pulse wonder spray (@5kg/ha) and trap for reducing pest incidence were included under this study. In terms of yield, farmers received an average yield of 854 - 985kg/ha of blackgram variety VBN 8 against 734 kg/ha of old blackgram VBN 4 variety. The highest gross income of Rs.31200 - 39650/ha were also realized from blackgram followed by VBN 8. Highest benefit-cost ratio (2.9-3.0) was realized in case of blackgram variety VBN 8 compared to farmers practices with old variety (2.2-2.4). Based on the experiment it can be concluded that the cultivation of blackgram VBN 8 recorded more profit. Hence, new blackgram VBN 8 variety in rainfed condition is a viable option for combating negative impacts of climate change. The farmers expressed their preference (per cent) for blackgram variety VBN 8 on the aspects like less pest and disease resistance (83%), grain yield (78%), climate variation resistance (58%), time of maturity (76%), ease of processing during harvesting (89%), socio-cultural compatibility (74%) and market price (65%). Improved crop varieties are widely accepted as primary input for guaranteed increase in production and productivity under various situations

Keywords: Climate change; climate resilient technology; blackgram; productivity; farmers adoption.

1. INTRODUCTION

The increasing CO_2 concentration is posing a serious threat as it leads to an increase in the average global temperature but the same has been positively correlated with increased biomass and yield particularly in C3 plants. Pulses are reported to be particularly sensitive to heat stress; a short span exposure to high temperature at flowering stage can cause heavy yield losses through flower dropping and poor pod setting. The predicted changes in temperature and their associated impacts, water availability, pests, disease and extreme whether events are likely to affect potential of pulse production. Major pulses such as blackgram, pigeon pea grown under rainfed conditions are subjected to multiple stresses like severe drought, high and low temperatures, high solar radiation, salinity etc., if this present trend continues in the rainfed area, the adverse situation will more pronounce in pulse production. Under such circumstances, an appropriate climate policy should be implemented to minimise the effects of climate change at farm, regional, national and international level. Hence, the World Bank supported TNIAM (Tamil Nadu Agriculture Modernization) project is mega project implemented with the objectives of enhancing the productivity and climate resilience of irrigated agriculture, improve water management and increase market opportunities for farmers in agro entrepreneurs in 66 sub basins in 4778 tanks covering 5, 43,000 ha in Tamil Nadu.

Now a day's climate change is one of the most important factors that largely affects the crop productivity, particularly in dryland crops. Unusual increase in temperature and unexpected torrential rainfall during the growth period especially at the time of flowering and pod formation results in forced maturity and poor yield in pulse crops. Similarly aberration of rainfall pattern correlated with humidity and associative impacts facilitate pest and disease incidences and other abiotic stresses like drought, flood, high salinity, soil acidification, water logging etc. [1]. Drought is a major problem where the area constantly receives less than annual average rainfall and considered as major constraint in attaining target in food production. Among the different stresses, drought stress occurs over 1.2 billion hectares of rainfed agricultural land, reducing crop yield worldwide [2]. During drought, plants are enforced to exhibit physiological, biochemical and molecular responses at whole plant and cellular levels. Though the crop has potential to give yield is on the ascending side, the major concern impeding yield potential by the stress. Variations in climatic factors affect plant growth and development adversely and that results in the dramatic reduction of crop yield up to 30 per cent [3,4].

Pulses are essential in human diet providing a major source of dietary protein. Among the

different pulse crops, blackgram is one of the important legume which is well suited under intensive cropping systems due to its short duration. The total area under blackgram cultivation in India is 56.02 L. ha with a production of 30.60 L.T. The average productivity of blackgram in India is 546 kg/ha. In Tamil Nadu, it is cultivated in 4.30 lakh hectare with a production of 3.11 lakh tone [5]. The potential of blackgram is very less because of the fact that the crop is mainly grown in rain-fed condition with poor management practices and also due to various physiological, biochemical and inherent factors associated with the crop [6,7].

Farmers generally take up sowing with the basal application of nutrients as recommended and there is no regional recommendation of foliar nutrition during the crop growth period. Further, soil application of nutrients is often not enough to meet the growing crop demand particularly in short duration crop like black gram, as it is basically indeterminate in habit of flowering and fruiting, there is a continuous competition for available assimilates between vegetative and reproductive sinks throughout the growth period. Foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating the easy entry of complete nutrients with remarkably rapid absorption and elimination of leaching losses and fixation. Under reduced soil nutrient availability and root activity condition under rainfed or drought situation, foliar nutrition plays a vital role for getting more yield per unit area [8].

Blackgram as a pulse specially need more amounts of Ca, Mg and S out of 16 essential elements. But soil applied nutrients may or may not be available to plants due to several soil physico-chemical reactions and the entire fertilizer is not utilized by the crop within the season especially relating to short duration crops. Hence, supplying nutrients through foliage improves the quality of produce by reaching the site of food synthesis directly and preserves the crop yields with low environmental impact [9]. Of the micronutrients, foliar application of phosphorus, zinc and iron brings the greatest benefit in comparison with addition to soil where phosphorus becomes fixed in a form inaccessible to the plant and where zinc and iron are less available. In tropical countries, drought has been identified the main constraint leading to the reductions in crop yields [10]. It is a well known fact that the various physiological and metabolic activities in plant are affected by scarcity of water. Due to drought, there is a significant reduction in growth, chlorophyll, and water contents and different fluorescence parameters are changed [11]. In pulse crop, drought at flowering and post-flowering stages of pulse crops has been found to have a greater adverse impact than at the vegetative stage [12]. So getting sustainability in pulse productivity and to have additional income per unit area, all these problems need to be solved. To meet these emerging challenges of climate change, there is an urgent need for developing promising technologies for mitigation and adaptation to combat adverse impacts of climate change [13]. Hence the present interventions were under taken to increase the pulse production in rainfed situation.

2. MATERIALS AND METHODS

2.1 Details of the Study Area

The study was conducted in Mohanur block in Namakkal district is located and about 143 meter above sea level. Located at latitude 11°05' 98.75" N, longitude 78° 14' 21.89"E. A study was undertaken to assess the influence of adoption of climate resilient technologies in yield of blackgram and on changes of farmers' income under dry land condition at Mohanur block of Namakkal district. The villages covered under the study were Andapuram, Parali and Arur in Mohanur Taluk, Namakkal district. Through field survey and farmers meeting at farm-level information were collected during January, 2019. The criteria of selection based on the consideration that the farmers were growing blackgram continously and marked them to earn income under rainfed situation.

2.2 Soil and Irrigation Resources

It receives 401.5 mm rainfall per annum, with annual temperature ranging from 18^0C to 41^{0C}. The study area is covered with Alfisols. Karaipottanar also called as Karuvettar is one among the part of Cauvery basin. Karuvattar River originates from Kolli Hills in the northern part of Namakkal District. The Total Length of Karaipottanar river is about 54 Km. In this subbasin there are 28 numbers of Tanks and 54 numbers of Anicuts with the total ayacut of 4055.87 Ha. This subbasin receives rainfall mainly in South West Monsoon Period with average annual rainfall of 401.50 mm. The entire sub basin area comprises of Garentiferous Gneisses, Charnockite and Quartzite. Namakkal district is underlain entirely by Archaean

Crystalline formations with recent alluvial deposits occurring along the river courses and Colluvium at the foothills. The soil type of the experimental farm was sandy loam with low in Organic carbon content (0.32 per cent) with a pH value of 7.2 and EC of 0.21dS/m, and the fertility level falls under low in available N(168.4 kg/ha) and available P (6.9 kg/ha) and medium in available K (288.7 kg/ha).

2.3 Technologies Intervention

Constraints faced by the farmers of Karaipottanar sub basin are documented through walk through survey conducted during 2018-19 and from secondary data collected from Government records. Based on the documentation, crop wise interventions proposed and approved for implementation. With a decreasing area under cultivation of pulses especially blackgram, the possibilities to improve the production of pulses through the adoption of improved packages of practices such as use of high yielding climate resilient mosaic resistant variety in blackgram (VBN 8), application of *biofertilizers*, recommended dose of NPK, Pulse wonder @5kg/ha spray and installation of pheromone trap were implemented during 2019,2020,and 2021 (Three years). The seed was sown in *rabi* season and recommended practices were adopted as per the crop production guide.

3. RESULTS AND DISCUSSION

3.1 Climate Variations

The Month wise temperatures, rainfall, relative humidity and wind speed was recorded for three years (Table 1) and quantity of rain received during cropping period (June to August) is presented in Fig. 3 and Fig. 4. The totalrainfall had of 2019, 2020 and 2021 are 485,655, and 982 mm, respectively. Max and Minimum temperatures of 2019, 2020 and 2021 are respectively. The maximum and minimum relative humidity of 2019, 2020 and 2021 has recorded 55.7 (December) and 73.2 (April), 26.4 (December) & 84.6 (April), 57.4 (December) & 85.6 (January) respectively deviated from 2019-2021. More sun shine hours of 657.2, 638 and 657.2 are recorded during Aprilin 2019, 2020 and 2021.Similarly low and high wind speed of 10.9 (August) and 10.2 (August), 11.1(July) &3.9 (January), 3.2 (December) & 3.5 (January) are also recorded and found more during July to August and minimum during December to January in all the three years.

The season wise temperature, rainfall, relative humidity and wind speed was recorded for three years is presented in Fig. 3 and Fig. 4. The totalrainfall had of 2019, 2020 and 2021 are 55.5, 140.3, and 169.9 mm, respectively. Max and Minimum temperatures (°C) of 2019, 2020 and 2021 are respectively. The maximum relative humidity of 60.0, 63.5 and 68.4 and minimum relative humidity (%) of 55.7, 56.4, 56.0 during 2019, 2020 and 2021 respectively deviated from 2019-2021. More sun shine hours (cal/cm^2) of 657.2, 638.0 and 657.2 during April and minimum sun shine(cal/cm^2) hours 360.1, 311.8 and 306.8 during December and January in 2019, 2020 and 2021 are recorded respectively. More wind speed (km/hr) of 10.9,10.2 and 11.1 during April and minimum sun shine (cal/cm^2) hours 3.9, 3.2 and 3.8 during December and January in 2019, 2020 and 2021 are recorded respectively. Similarly low and high wind speed of 10.9 (August) and 10.2 (August), & 11.1 (July) are also recorded and found more during June to August in all the three years.

3.2 Performance of Climate Resilient Technologies in Blackgram Productivity

The yield and income accrued to the farmers from the blackgram cultivation with improved technologies under rainfed condition is presented in Table 2. The crop resulted more yield and thus proved highly profitable. It consisted of the monetary valueof all products and by-products like stalk. It was foundthat on an investment of Rs 15,000/ha, average net income of Rs.31200-39650/ha was realized. The cost-benefit ratio was 2.9-3.0. In terms of yield, farmers received an average yield of 854-985kg/ha of blackgram variety VBN 8 against 734 kg/ha of old blackgram VBN 4 variety under farmers practices. [14] also reported that identification of better lines would be helpful in the process of improving castor productivity and production under rainfed situation.

3.3 Economic Difference of Blackgram under Different Management System

The economics of Blackgam variety VBN 8 was compared with old blackgram variety VBN 4 grown in the region (Table 2). The highest yield per hectare was recorded in case of blackgram VBN 8 8854-985kg/ha. The highest grossincome (RS.31200-39650/ha) was also realized from blackgram followed by VBN 8. Highest benefit-cost ratio (2.9-3.0) was realized in case of

blackgram variety VBN 8 compared to farmers practices with old variety (2.3). Based on the experiment itcan be concluded that the cultivation of blackgram VBN 8 recorded more profit. Hence, new blackgram VBN 8 variety in rainfed condition is a viable option for combating negative impacts of climate change.

3.4 Outlook on Superiority of New Blackgram Variety VBN 8 over Old Variety Blackgram VBN 4

The responses of the farmers were compared between the attributes of old blackgram VBN 4 and improved blackgram variety VBN 8 (Table 3). The farmers expressed their preference for blackgram variety VBN 8 on the aspects like less pest and disease resistance (83%), grain yield (78%), climate variation resistance (58%), time of maturity (76%), ease of processing during harvesting (89%), socio-cultural compatibility (74%) and market price (65%). Improved crop varieties are widely accepted as primary input for guaranteed increase in production and productivity under various situations [15]. However majority of the respondents preferred the local and old varieties in terms of ease of accessing and availability of seeds under regular cultivation.

Application of improved technologies viz., use of mosaic resistant new improved blackgram VBN 8 variety, recommended dose of fertilizer with bio fertilizer application, foliar spray of pulse wonder 5kg/ha and pheromone trap increased the yield parameters like numbers pod and grain yield. The increase in yield of blackgram might be due to reduces flower shedding, increases yield up to 20 % and increases drought tolerance mechanisms by the adoption of improved package of practices. Integrated nutrient application of application along with pulse wonder favourably recorded higher values of growth components *viz.,* plant height, number of pod per plant, number of pods plant^{-1}, seed and haulm yield of black gram. Besides improvement in source-sink relationship compared to other treatments also enhanced biometric, growth parameters and yield of black gram. Similar trend in blackgram was observed by [16,17,18]. [19,17] stated that foliar application of pulse wonder along with and optimum fertilizer application improved growth parameters, antioxidant enzyme activity and pigment content enabling plants to perform better under drought and limited water availability conditions. Similarly, the improved yield and benefit-cost ratio was also observed by the adoption of improved soil fertility management in black gram [20].

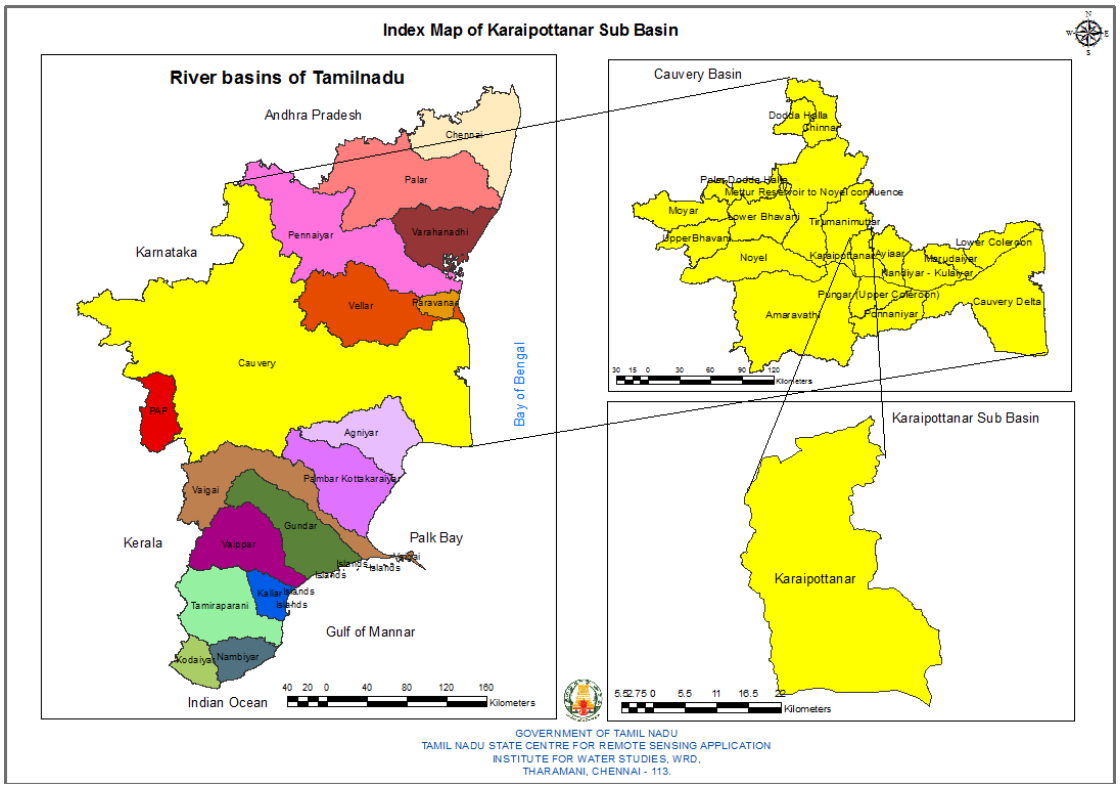

Fig. 1. Index map of Karaipottaanr Sub Basin

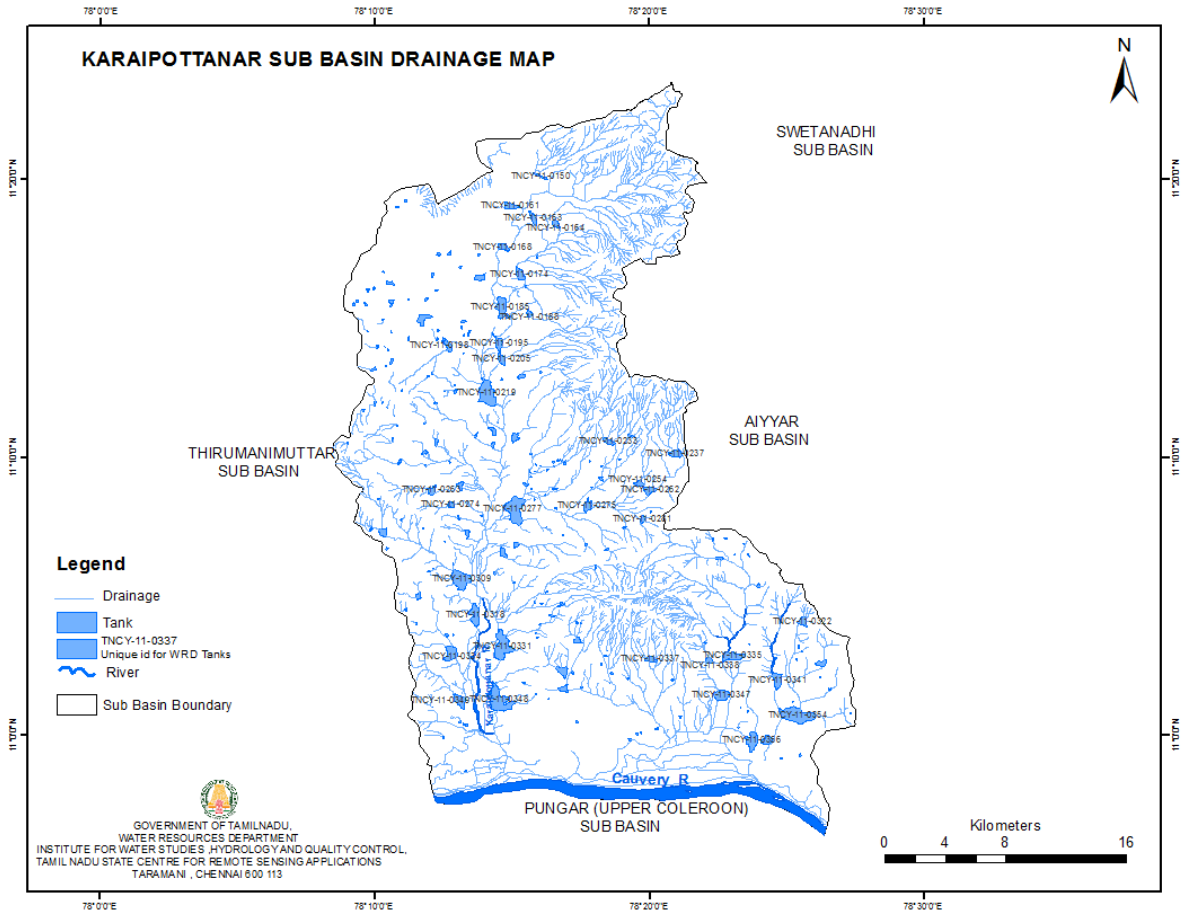

Fig. 2. Karaipottanar sub basin drainage Map

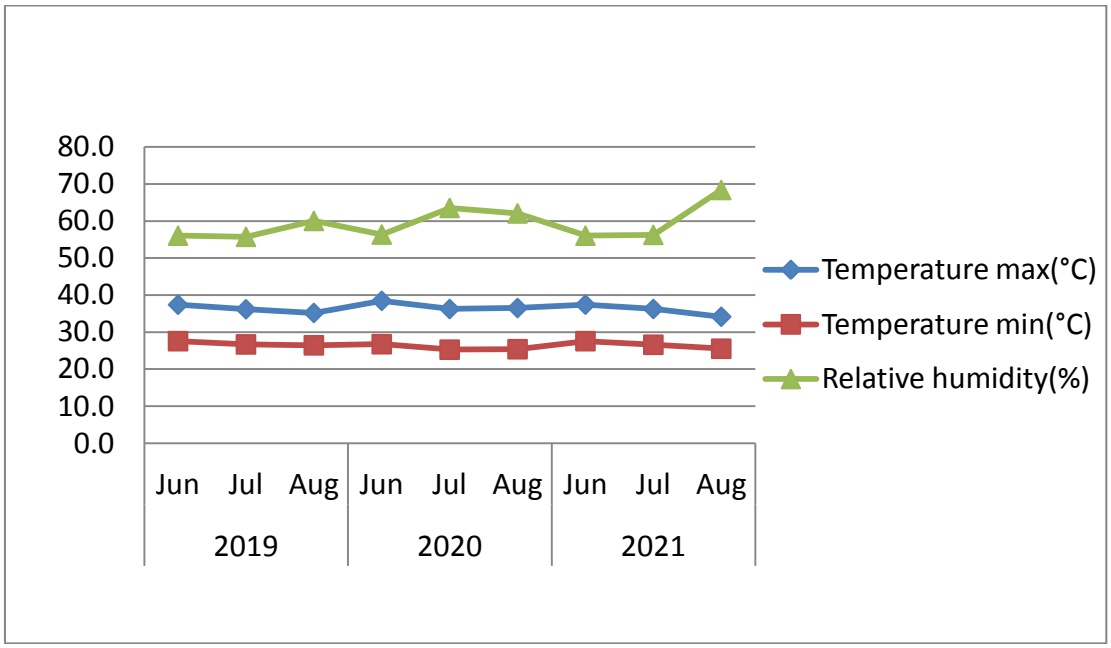

Fig. 3. Temperature and Relative humidity recorded during cropping period

Table 1. Month wise meteorological parametersrecorded during the programme

Year	Month	Sun Shine (cal/cm2)	Temperature max(°C)	Temperature min(°C)	Relative humidity (%)	Wind speed (Kmph)	Rain fall(mm)
2019	Jan	531.7	30.9	18.8	71.9	3.9	0.0
	feb	577.4	33.8	21.7	69.4	4.9	0.0
	Mar	643.7	36.0	22.1	63.2	4.3	0.0
	Apr	657.2	37.9	24.8	60.4	4.3	0.0
	May	644.7	39.0	29.2	57.4	6.7	0.5
	Jun	611.2	37.4	27.6	56.0	10.1	0.2
	Jul	569.1	36.2	26.7	55.7	10.8	0.7
	Aug	512.7	35.2	26.4	60.0	10.9	0.9
	Sep	540.8	34.6	25.7	70.9	8.1	5.0
	Oct	481.9	34.1	24.9	80.1	4.0	3.9
	Nov	431.8	36.4	23.7	76.4	4.1	2.5
	DEC	360.1	32.7	22.0	78.8	4.6	2.5
2020	Jan	490.5	34.0	21.5	73.2	4.1	0.0
	feb	541.7	39.5	19.4	66.3	4.9	0.0
	Mar	613.1	40.2	22.5	64.6	4.9	0.3
	Apr	638.0	38.7	24.6	63.6	4.4	1.7
	May	592.0	41.1	26.0	59.6	5.6	0.5
	Jun	580.3	38.5	26.7	56.4	8.8	0.8
	Jul	532.5	36.2	25.3	63.5	7.2	1.0
	Aug	547.1	36.5	25.4	62.0	10.2	2.7
	Sep	503.2	35.1	24.9	69.1	7.5	5.4
	Oct	504.8	35.6	24.7	68.1	6.4	3.0
	Nov	397.2	31.6	23.7	81.5	3.4	3.3
	DEc	311.8	29.3	22.0	84.6	3.2	2.9
2021	Jan	306.8	29.8	22.2	85.6	3.5	3.0
	feb	577.4	33.8	21.7	69.4	4.9	0.0
	Mar	643.7	36.0	22.1	63.2	4.3	0.0
	Apr	657.2	37.8	24.8	60.4	4.3	0.1
	May	644.7	39.0	27.6	57.4	6.7	0.3
	Jun	611.2	37.4	27.6	56.0	10.1	1.1
	Jul	577.7	36.2	26.6	56.3	11.1	1.9
	Aug	523.8	34.2	25.5	68.4	8.2	2.6
	Sep	544.8	34.2	25.1	70.9	7.4	4.0
	Oct	481.9	33.3	24.6	82.9	5.4	6.6
	Nov	431.8	36.4	23.7	76.4	4.1	10.8
	Dec	408.8	30.0	21.9	84.9	3.8	1.7

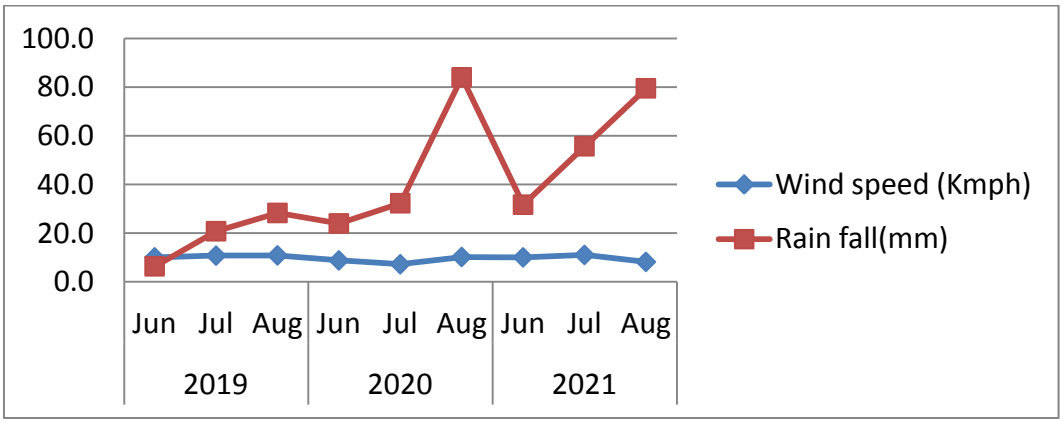

Fig. 4. Rainfall and wind speed recorded during cropping period

Table 2. Effect of climate resilient technology demonstration on yield parameters, yield, income and pest incidence of blackgram

S.No.	2019			2020			2021			Average		
	FP	RDF alone	Demo	FP	RDF alone	demo	FP	RDF alone	Demo	FP	RDF alone	Demo
Plant height (cm)	36.8	38.1	39.5	37.4	37.9	38.9	36.9	37.6	39.4	37.0	37.9	39.3
Pods per plant (Number)	25.8	25.6	36.4	24.9	27.4	34.8	24.9	26.4	35.0	25.2	26.5	35.4
Pod yield kg/ha	734	879	942	794	845	928	757	795	985	761.7	839.7	951.7
Hulm yield kg /ha	1186	1657	2450	1194	1495	2240	1190	1278	2640	1190.0	1476.7	2443.3
Net income (Rs./ha)	24540	33240	37020	28140	31200	36180	24900	28200	39600	25860.0	30880.0	37600.0
BC ratio	2.3	2.7	2.9	2.4	2.6	2.9	2.2	2.4	3.0	2.3	2.6	2.9
Sucking pest incidence /5 leaves/plant	15.4	12.5	6.5	15.0	13.4	5.9	16.1	14.9	7.2	15.5	13.6	6.5
Pod borer incidence (%)	31.98	21.45	15.19	32.88	20.31	16.08	31.58	19.39	15.02	32.1	20.4	15.4

Table 3. Distribution of respondent (farmers) on preference to improved blackgram VBN 8 variety (%)

S.No.	Particulars	Farmers preferences (%)		
		Existing practices	Intermediate	Improved practices
1.	Accessibility and availability of seed	34	04	62
2.	Grain yield	10	12	78
3.	Low input requirement	29	34	37
4.	Pest and disease resistance	8	9	83
5.	Climate variation resistance	8	34	58
6.	Time of maturity	12	12	76
7.	condition of crop during rain and less moisture condition	15	3	82
8.	Ease of processing during harvesting due to synchronized maturity	6	5	89
9.	Socio-cultural compatibility	10	16	74
10.	Market price	16	29	65

4. CONCLUSION

Recently many technologies were developed to increase food production, which also useful in increasing yield under various biotic and non biotic stress condition. on the basis of the above intervention under rainfed ecosystem suitable crop variety like blackgram VBN 8 and better nutrient management with TNAU Pulse wonder (@5kg/ha) which has nutrients and growth regulators, especially to increase flower setting and grain yieldunder drought and rainfed situation which plays a major role in growth, development and metabolism of black gram. Thus, from this interventions, it could be concluded that recommended dose of bertilizers and NPK, pulse wonder @5kg/ha and pest management practices considered as important strategy to improve the productivity and profitability of black gram under rainfed situation. Resistance to biotic and abiotic stresses, high yield and superior quality of VBN 8 proved major attributes that determined its adoption and play a central role in livelihood security of farmers under low rainfall areas. Better economic return and sustainable flow of income convinced the farmers to adopt the improved blackgram variety.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Agrawal SK. Effects of heat stress on physiology and reproductive biology of chickpea and lentil; 2017. Available:http://hdl.handle.net/20.500.1176
2. Kijne JW. Abiotic stress and water scarcity: Identifying and resolving conflicts from plant level to global level. Field Crops. Research. 2006;97(1):3–18.
3. Baroowa B, Gogoi N. Effect of induced drought on different growth and biochemical attributes of blackgram (*Vigna mungo* L.) and green gram (*Vigna radiata* L.). Journal of Environmental Research and Development. 2012;6(3A):584–593.
4. Gill SS, Anjum NA, Hasanuzzama M, Gill R, Trivedi DK, Ahmad I, et al. Glutathione and glutathione reductase: A boon in disguise for plant abiotic stress defense operations. Plant Physiology and Biochemistry. 2013;70:204–212.
5. Tamil Nadu Salient statistics on Agriculture. Agriculture Department, Secretariat, Government of Tamil Nadu, Chennaip. 2021;14.
6. Devaraju B, Senthivel T. Effect of foliar application of different sources of nutrients on growth and yield of blackgram under irrigated conditions. Int. J. Curr. Microbiol. App. Sci. 2018;7(1):3105-3109.
7. Singh S, Singh YP, Tomar SS. Review on climatic abnormalities impact on area, productivity of central India and strategies of mitigating technology on yield and benefits of black gram. J. Pharm. Phytochem. 2018;7:1048-1056.
8. Girija Prasad Patnaik, Thavaprakaash N. Foliar nutrition –a boon to pulse farmers. Kisan World. 2019;49.
9. Jeevana Lakshmi E, Ramesh Babu PV, Prabhakar Reddy G, Umamaheswari P,

Pratap Kumar Reddy A. Effect of foliar application of secondary nutrients and zinc on growth and yield of Blackgram. International Journal of Chemical Studies. 2017;5(6): 944-947.

10. Juthika Saikia, Rupak K. Sarma, Rajashree Dhandia, Archana Yadav, Rupjyoti Bharali, Vijai K. Gupta, Ratul Saikia. Alleviation of drought stress in pulse crops with ACC deaminase producing rhizobacteria isolated from acidic soil of Northeast India; 2018. Scientific Reports.*8:3560.* Available:www.nature.com
11. Swati Shahi, Rajnish Kumar, Malvika Srivastava. Response of black gram (*Vigna mungo*) to potassium under water stress condition. Annals of Plant and Soil Research. 2019;21(1):93 –97.
12. Cayalvizhi B. Sai, Parameswaran Chidambaranathan. Reproductive stage drought tolerance in blackgram is associated with role of antioxidants on membrane stability. Plant Physiol. Rep. 2019;24(3):399–409.
13. Anurag Bera. Impact of climate change on pulse production and it's mitigation strategies. Asian Journal of Advances in Agricultural Research. 2021;15(2):14-28.
14. Geetha A, Shankar GG, Priya B. Variability of physiological and yield parameters of castor genotypes under rainfed conditions. Journal of Pharmacognosy and Phytochemistry. 2019;8(1):197-199.
15. Chindi A, Shunka E, Solomon A, Gebremedhin WG, Seid E, Tessema L. Participatory potato seed production: A breakthrough for food security and income generation in the central highlands of Ethiopia. Open Agriculture. 2017;2(1):205-212.
16. Balaji P, Vinod Kumar SR, Srinivasan G, Kancheti Mrunalini. Effect of foliar nutrition on yield maximization strategies for irrigated black gram cv. ADT 3. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):2884-2886.
17. Sachin AS, Sivakumar T, Krishna Surendar K, Senthivelu M. Influence of plant growth regulators and nutrients on biometric, growth and yield attributes in black gram (*Vigna mungo* L.). Journal of Agriculture and Ecology. 2019;1(7):55-63.
18. Karthikeyan A, Vanathi J, Babu S, Ravikumar C. Studies on the effect of foliar application of organic and inorganic nutrients on the phenotypic enhancement of black gram cv.Vamban-6. Plant Archives. 2020;20(2):1161-1164.
19. Ramesh T, Rathika S, Sangeetha S, Satheesh S, Ponpradeepa M, Pavithra AM. Enhancement of black gram productivity through foliar spray of nutrients and growth hormones - a review. Int. J. Curr. Microbiol. App. Sci. 2020;9(12):1594-1603.
20. Tomar RK, Sahu BL, Singh RK, Prajapati RK. Productivity enhancement of blackgram (*Vigna mungo* L.) through improved production technologies in farmers' Held. Journal of Food Legumes. 2009;22(3):202-204.

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