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Impact of Frontline Demonstration and Weather Relations on Seed Yield and Economics of Pigeonpea in Warangal District of Telangana

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ABSTRACT

Pigeonpea is generally grown in poor/marginal soils with a minimum use of resources and very low water footprint. The average yield in Warangal District is substantially low (530 kg ha^{-1}) leading to great scope for increasing the productivity. Current study aimed in conducting frontline demonstrations on the improved varieties/cultural practices of pigeonpea. A total of 142 FLDs were conducted in farmer's field across 97 villages in the Warangal District on pigeonpea varieties (WRG-27, LRG-41, WRG-53, WRG-65, ICPL-87119, ICP-8863) during 2012-13 to 2019-20 and further weather relations were worked out. Average seed yield of 1531 kg ha^{-1} was obtained in demonstrated plot over control (1175 kg ha^{-1}) with an additional yield of 356 kg ha^{-1} and productivity by 30.3%. Higher net profit (Rs 57, 120) and B:C ratio (0.70 to 1.78) were observed under demonstrated plots with improved practices as compared to farmer's practice (Rs 41,494 and 0.56 to 1.35). Tmin (0.192*) and RH (0.225**) positively correlated while solar radiation (-0.622**) and wind speed (-0.188**) were negatively correlated with seed yield. Through large scale demonstrations of improved technologies/varieties, productivity can be significantly increased in pigeonpea thus improving the economic returns of the farmers.

Keywords Seed yield, Pigeonpea, Net returns, Frontline, Impact.

INTRODUCTION

Pulses constitute the major and cheapest source of protein for the Indians. India is the largest producer and consumer of pulses in the world. Pulses play an

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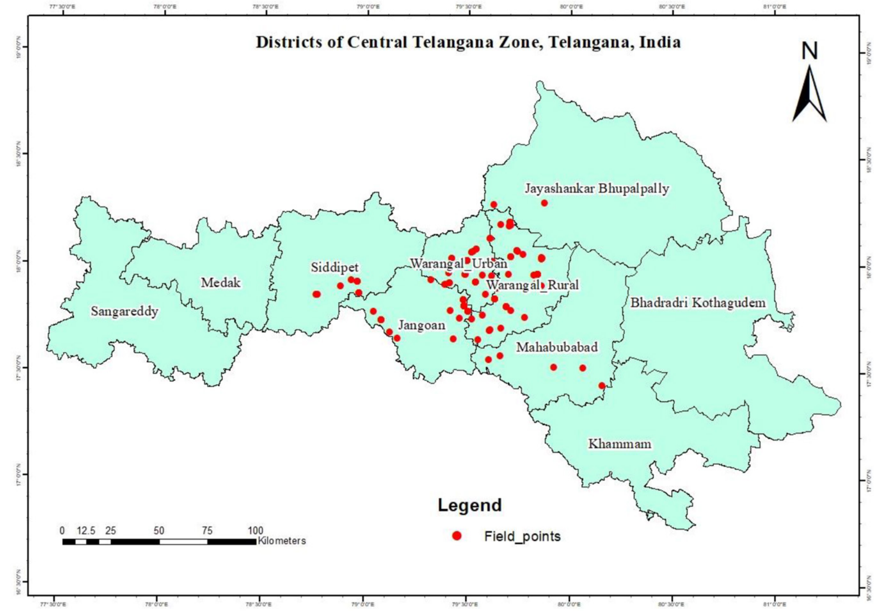

Fig. 1. Location (n = 142) map of pigeonpea frontline demonstrations in erstwhile Warangal District of Telangana over eight years period.

important role to enhance the fertility of soil in terms of yield of subsequent crop to the tune of about 20-40% has been recorded (Joshi and Rao 2017). Pulses are an integral part of many diets across the globe and they have great potential to improve human health, conserve soil, protect the environment and contribute to global food security, besides serving as an important source of protein for a large portion of the global population (Smita and Satyasai 2015).

In India, yield gap is very high as compared to other countries yield in different crops ranging up to 60% (Mondal 2011). The area under pulses has increased from 19 million hectares in 1950-51 to 29.4 million hectares in 2017-18, but pulses productivity in India is very low i.e., 1.28 billion, per capita consumption of pulses has been falling constantly due to stagnant production and productivity (Chaturvedi *et al.* 2019). This has been due to the presence of a number of impediments in pulse production in India, such as higher yield gaps, abrupt climatic changes, attack of pests and diseases, lack of quality seeds, low adoption rates. By 2050, the domestic requirement would be 26.50 mt, in order to feed the population necessitating stepping up the additional produce at 1.86% annual growth rate (Masood and Gupta 2012). Closing the gap between demand and supply, pulses would require production to grow at least by 4% per annum (Kumar 1998). Martolia (2015) stated that the domestic demand of pulses is very high therefore the escalating population leads to reduction in per capita availability.

In Telangana, pigeonpea accounts for only 7.42% of area and 6.32% of production of the country. However, the average yield in Warangal District is 530 kg ha^{-1}, which is substantially low. Pigeonpea is generally grown in poor/marginal soils not suited to other crops, with a minimum use of resources and have a very low water footprint. There is great scope for increasing the productivity of pigeonpea, especially in Central Telangana region. Keeping in view this fact, frontline demonstrations were planned by AICRP on pigeonpea, Warangal on the improved varieties/cultural practices of pigeonpea for eight consecutive years from 2012-13 to 2019-20.

MATERIALS AND METHODS

The experimental details

The study was conducted during 2012-20 by AICRP on pigeonpeain erstwhile Warangal District in 89.4 ha

Table 1. Pigeonpea frontline demonstration of package technology over farmers practice at Warangal of Telangana during 2012-2020 (n=142).

Year	Villages	Area (ha)	No. of farmers	Seed yield (kg ha^{-1}) Farmers' practice	Demons-tration yield	% in-crease	Net returns (Rs ha^{-1}) Farmers practice	Demons-tration yield	% in-crease	B:C ratio Far-mers' prac-tice	Demon-stration yield
2012-13	30	14.0	32	879	1160	32.0	18510	26514	43.2	0.56	0.70
2013-14	8	12.4	25	1134	1518	33.9	27635	39381	42.5	0.83	1.03
2014-15	17	11.0	25	994	1301	30.9	38176	52436	37.4	1.05	1.27
2015-16	9	10.0	11	1119	1554	38.9	60343	88805	47.2	1.34	1.78
2016-17	11	10.4	10	1178	1470	24.8	41489	53810	29.7	0.92	1.06
2017-18	8	10.4	8	1399	1765	26.2	40760	54130	32.8	0.91	1.08
2018-19	9	10.4	9	1345	1699	26.3	44450	58528	31.7	0.99	1.17
2019-20	5	10.8	22	1355	1782	31.5	60590	83356	37.6	1.35	1.67
Total/ Mean	97	89.4	142	1175	1531	30.3	41494	57120	37.7	0.99	1.22

area which is located at 17°19′ to 18°13′ N latitudes and 78°49′ to 80°43′E longitudes in Telanganastate. Therefore, the present investigation was carried out in ninety seven villages covering 29 mandals of the district in eight years period with 142 farmers as sample size. Location map of pigeonpea frontline demonstrations was represented in Fig. 1. The soil of the district comprises of sandy loam with patches of shallow black cotton soils. Medium and deep black cotton soils are also seen at various places. Each frontline demonstration was laid out on 1.0 acre area while adjacent 1.0 acre was considered as control for comparison (farmer's practice). By providing all the recommended package of practices like the improved seed (WRG-27, LRG-41, WRG-53, WRG-65, Asha and Maruthi), use of bio control agents (Trichoderma and Pseudomonas) enriched FYM, seed treatment with thiram or captan, Rhizobium and Trichoderma, recommended dose of fertilizers and timely application of herbicide and plant protection chemicals as prescribed by PJTSAU were demonstrated. The farmer practice was considered as control plot/local check in demonstration cluster. The demonstrations were laid out under the close supervision of the Scientists. The study was conducted in experimental designs ('Control-Treatment' and 'Before-After') of social research.

Data collection and analysis

The data on output were collected from FLDs immediately after harvesting to assess the impact of FLDs intervention on the yield of pigeonpea (2012-20) as well as local plots by scientists with frequent field visits during 2012-13 to 2019-20 and finally the seed yield, cost of cultivation, net returns and benefit cost ratio were worked out. However, structured and pre-tested interview schedule was used to elicit the information from beneficiary farmers about adoption and horizontal spread of pigeonpea technologies in selected villages. Field days were also conducted in each cluster to show case the results of FLDs to the farmers of the same village and neighboring villages. More than 10% difference between demonstration and farmers practice' was considered as significant difference. The following formulae were used to assess the impact of FLDs on the different parameters.

$$\text{Impact on adoption (\% change)} = \frac{\text{No. of adopters after demonstration} - \text{No. of adopters before demonstration}}{\text{No. of adopters before demonstration}} \times 100$$

$$\text{Impact of horizontal (\% change)} = \frac{\text{Area after demonstration (ha)} - \text{Area before demonstration (ha)}}{\text{Area before demonstration (ha)}} \times 100$$

The extension gap, technology gap and technology index were calculated using the formula as suggested by Samui *et al.* (2000). Yield gap in pulses (yield

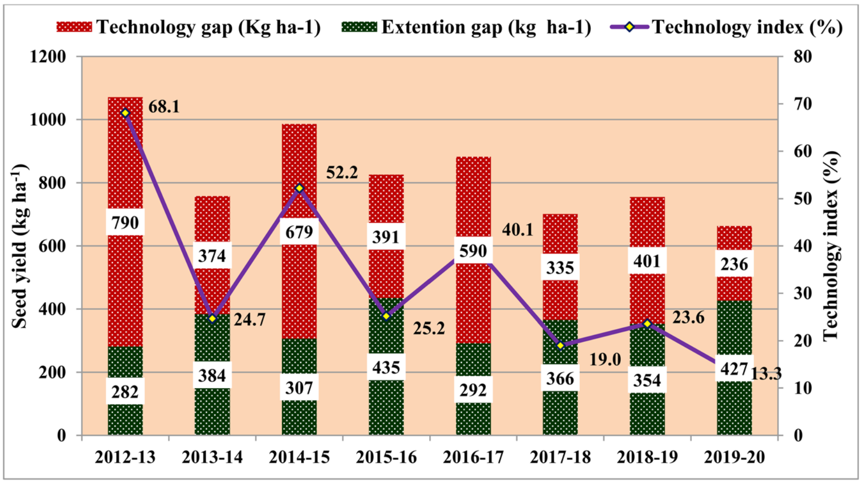

Fig. 2. Impact of frontline demonstrations on technological gap, extension gap and technology index of pigeonpea in erstwhile Warangal District of Telangana.

gap-I and yield gap-II) were analyzed with the help of following formula :

Yield Gap-I (Technology gap) = Potential yield - Demonstration yield,

Yield Gap-II (Extension gap) = Demonstration yield- Farmers / Traditional yield,

Technology index (%) = {(Pi-Di) / Pi }X 100,

Where, Pi= Potential yield of the crop, Di= Demonstration yield of the crop,

Yield gap/impact on yield (% change) = {(Di-Fi) / Fi} × 100,

Where, Di= Demonstration yield of the crop, Fi= Farmers yield/check yield.

Daily values of the meteorological elements viz., Tmin (°C), Tmax (°C), average relative humidity (%), rainfall (mm), solar radiation (MJ m^{-2}), wind speed (m s^{-1}) were collected from the NASA satellite and model-derived weather data (Bai *et al.* 2010) statistically analyzed with SPSS software.

RESULTS AND DISCUSSION

Impact of FLDs on seed yield of pigeonpea

Table 2. Overall yield gap analysis in pigeonpea in Warangal (n = 142). * Yield gap I = Technology gap, Yield gap II = Extension gap.

Variety	Average yield (kg ha^{-1}) Potential yield (A)	Demonstration yield (B)	Farmers yield (C)	Yield gap I (kg ha^{-1}) A-B	Yield gap II (kg ha^{-1}) B-C	Yield gap (%) (B-C/ B)*100	Technology index (%) (A-B/A)*100
ICP-8863	1600	1161	832	439	329	28.4	27.4
ICPL-87119	1800	1730	1343	70	387	22.4	3.9
LRG-41	1800	1346	1023	454	323	24.0	25.2
WRG-27	2000	1528	1153	472	376	24.6	23.6
WRG-53	2000	1572	1160	428	412	26.2	21.4
WRG-65	2100	1496	1148	604	348	23.3	28.8

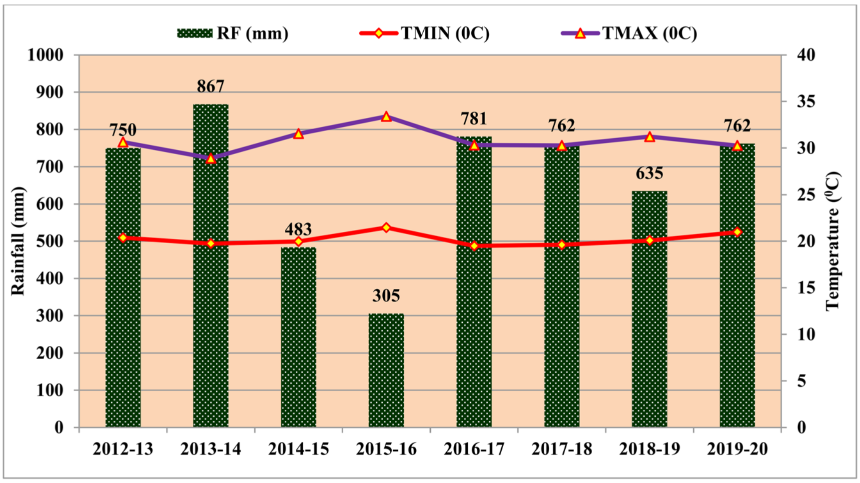

Fig. 3. Average rainfall, minimum and maximum temperature recorded in erstwhile Warangal during 2012-20 (n=142).

The seed yield of pigeonpea under FLD varied from 1160 kg ha^{-1} to 1782 kg ha^{-1}, however in farmer's practice seed yield varied from 879 kg ha^{-1} to 1399 kg ha^{-1}. In FLD plots significantly mean higher seed yield 1531 kg ha^{-1} was recorded as compared to farmer practices (1175 kg ha^{-1}) (Table 1). In demonstration plots the increase in seed yield ranged from 24.8% (2016-17) to 38.9 % (2015-16). Over the years mean percent increase recorded was 30.3 %. These results corroborates with findings of Lalit *et al.* (2015), Kumar and Kispotta (2017). The superior seed yield of pigeonpea crop obtained under FLD was due to the use of improved variety, recommended seed rate and spacing, seed treatment, use of Rhizobium biofertilizers, recommended dose of fertilizers, pre-emergence weed management and integrated-pest management. It might be due to the various factors like social and economic conditions and prevailing microclimatic conditions, which affect the yield of this crop. Kumar *et al.* (2019), Kaur *et al.* (2014) also reported that use of recommended practices for pigeonpea cultivation improved seed yield.

The extension gap varied from 282 kg ha^{-1} to

Table 3. Impact of frontline demonstrations on adoption of pigeonpea production technologies (n=142).

Sl. No.	Technology	Adoption (n=142) Before demonstration	After demonstration	Change in no. of adopters	Impact (% Change)
1	Land preparation and FYM application	180 (93.8)	192 (100.0)	12	6.7
2	Improved varieties	41 (21.4)	188 (97.9)	147	358.5
3	Seed rate	39 (20.3)	148 (77.1)	109	279.5
4	Seed treatment + Rhizobium, PSB, Trichoderma	20 (10.4)	174 (90.6)	154	770.0
5	Sowing time and spacing	127 (66.2)	170 (88.5)	43	33.9
6	Fertilizer management	98 (51.0)	189 (98.4)	91	92.9
7	Weed management	24 (12.5)	184 (95.8)	160	666.7
8	One life saving irrigation (bud initiation stage)	20 (10.4)	102 (53.1)	82	410.0
9	Plant protection chemicals	58 (30.2)	192 (100.0)	134	231.0
10	Recommended yield	24 (12.5)	178 (92.7)	154	641.7
				Over all impact	349.1

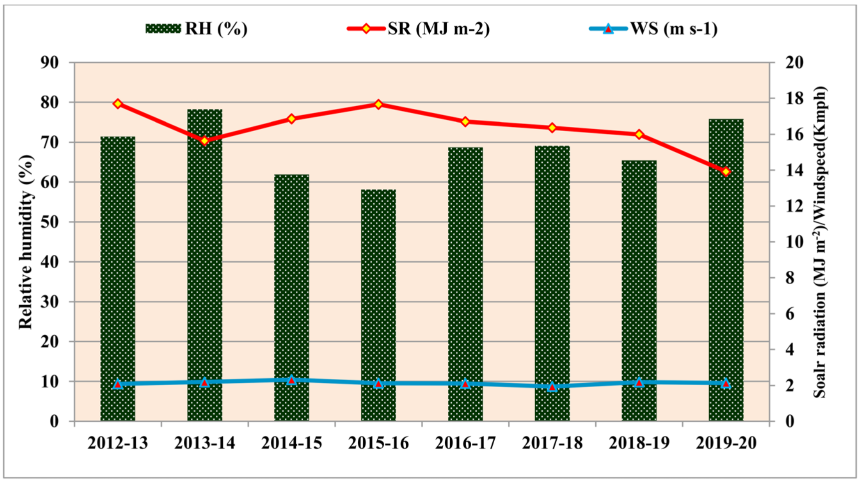

Fig. 4. Average relative humidity, solar radiation and wind speed recorded in erstwhile Warangal during 2012-20 (n=142).

435 kg ha^{-1}during the period of study (Fig. 2). The average extension gap was observed 356 kg ha^{-1}which emphasized the need to educate the farmers through various extension means i.e., FLD for adoption of improved production technologies, to revert the trend of wide extension gap. The technology gap ranged from 236 kg ha^{-1} to 790 kg ha^{-1} during the study period. The average technology gap was observed 475 kg ha^{-1}. The technology gap observed may be attributed to dissimilarity in the crop management practices, soil fertility status and local climatic situation. Technology index varied from 13.3% to 68.1% with a mean of 31.0% revealing the scope of evolved technology at the farmer's field (Fig. 2). The lower is the value of technology index, the more is the feasibility of technology demonstrated was also reported by Lalit *et al.* (2015), Singh *et al*. (2017).

Impact of FLDs on economics of pigeonpea

The inputs and outputs prices of commodities prevailed during the study of demonstration were taken for calculating net return and benefit : Cost ratio (Table 1). The cultivation of pigeonpea under farmer practice recorded varied net returns of Rs 18510 to 60343 ha^{-1}, as compared to demonstration (Rs 26514 to 88805 ha^{-1}). Similar findings were reported by Singh *et al.* (2014). An average net return and B:C of control plot was Rs 41494 ha^{-1} and 0.99 respectively as compared to improved practice (Rs 57120 ha^{-1} and 1.22). The higher benefit cost ratios were the evidences that the intervention of technologies is economically feasible and convincing the farmers for the adoption. The variation in benefit cost ratio during different years may mainly be on account of yield performance and input output cost in that particular year. The B:C ratio under improved cultivation practices was higher than farmer's practices in all the years and this may be due to higher yield obtained under improved technologies compared to farmers practice. This finding is in corroboration with the findings of Kumar *et al.* (2021), Mokidue *et al.* (2011).

Table 4. Impact of frontline demonstrations on horizontal spread of varieties of pigeonpea in demonstrated area of Warangal District (n=142).

Sl. No.	Variety	Area (ha) Before demons-tration	After demons-tration	Cha-nge in area (ha)	Impact %) Change)
1	ICP-8863	1.8	6.5	4.7	261
2	ICPL-87119	3.8	11.5	7.7	203
3	LRG-41	17.8	41.5	23.7	133
4	WRG-27	2.4	7.8	5.4	225
5	WRG-53	10.0	25.0	15	150
6	WRG-65	23.6	124.4	100.8	427

Table 5. Correlation coefficient of weather variables with pigeonpea yield at Warangal District during 2012-20 (n=142). **Significant at the 0.01 level, * Significant at the 0.05 level. SY = Seed yield (kg ha^{-1}), RF = Rainfall (mm), T_{min} = Minimum temperature (^{0}C), T_{max} = Maximum temperature (^{0}C), RH = Relative humidity (%), SR = Solar radiation (MJ m^{-2}), Wind speed (m s^{-1}).

Parameters	SY	RF	T_{min}	T_{max}	RH	SR	WS
Seed yield (kg ha^{-1})	1.0						
Rainfall (mm)	0.141	1.0					
T_{min} (^{0}C)	0.192*	-0.348**	1.0				
T_{max} (^{0}C)	-0.128	-0.886**	0.574**	1.0			
Relative humidity (%)	0.225**	0.917**	-0.142	-0.885**	1.0		
Solar radiation (MJ m^{-2})	-0.622**	-0.434**	-0.096	0.480**	-0.583**	1.0	
Wind speed (m s^{-1})	-0.188*	-0.440**	-0.346**	0.025	-0.308**	0.054	1.0

Overall yield gap analysis among different varieties of pigeonpea

The overall yield gap analysis among the varieties of pigeonpea in Warangal District recorded higher technology gaps (gap-I) than extension gap (gap-II) (Table 2). Among different varieties of pigeonpea, ICP-8863 recorded more yield gap (28.4 %) followed by ICPL-87119 (22.4 %) and WRG-65 (23.3%). In pigeonpea, yield gap-I ranged from 70 to 604 kg ha^{-1}, where as yield gap-II ranged from 323 to 412 kg ha^{-1}. The technology index of the pigeonpea varieties found that variety ICPL-87119 (3.9%), WRG-53 (21.4 %), WRG-27 (23.6%), LRG-41 (25.2%) was more feasible than variety WRG-65 (28.8%) and ICP-8863 (27.4%). Hence, there is need to develop location specific and low cost technology of pulses to the farmers with suitable extension interventions at farmers' field. These findings were consistent with the findings of Kumbhare *et al.* (2014), Dutta (2014).

Impact of FLDs on adoption of pigeonpea production technologies.

Data on adoption of pigeonpea production technologies by the beneficiary farmers are presented in Table 3. It was found that a number of adopters for land preparation and application of FYM to pigeonpea were 93.8% before demonstrations, which increased to 100.0% after frontline demonstrations in 97 villages. A similar trend was also observed in the case of plant protection chemicals as an increase in the percentage of adopters from 30.2 to 100.0%. The number of adopters for application of fertilizers and use of improved varieties of pigeonpea viz., ICPL-87119, WRG-65, WRG-53, WRG-27, ICP-8863 were increased significantly during pre and post-demonstrations period from 51.0 to 98.0% and from 21.4 to 97.9%, respectively. Similarly, trend was recorded in groundnut after FLDs activities (Patil *et al.* 2018). The FLDs intervention made highly positive impact on adoption of important seed treatment with Thiram, Rhizobium, PSB culture and *Trichoderma* (770%), weed management (666%) and one life saving irrigation (410%) in study area. Besides, the percentage of adopters for the use of recommended seed rate also increased from 20.3% before to 77.1% after frontline demonstrations in 97 villages. The mean adoption level of pigeonpea production technologies increased by 349.1% due to FLDs organized by the AICRP on Pigeonpea in all selected villages. Similar results in production technology adoption levels before and after the demonstrations in mungbean were reported by Meena and Singh (2017).

Impact of FLDs on horizontal spread of different varieties of pigeonpea

In the present study, efforts were made to study the impact of FLDs on the horizontal spread of different varieties of pigeonpea (Table 4). There was a significant increase in area from 23.6 to 124.4 ha under WRG-65, from 17.8 to 41.5 ha under LRG-41 and from 10 to 25 ha under WRG-53 variety in demonstrated area. The maximum area expanded was under WRG-65 variety. The reasons might be their agronomical attributes such as high yielding nature, indeterminate type of varieties, tolerant to Fusarium wilt and wider adoptability in the Telangana state. Impact studies revealed that FLDs organized

Table 6. Stepwise regression models relating weather parameters with seed yield. SY = Seed yield (kg ha^{-1}), RF = Rainfall (mm), T_{min} = Minimum temperature (^{0}C), T_{max} = Maximum temperature (^{0}C), RH = Relative humidity (%), SR = Solar radiation (MJ m^{-2}), Wind speed (m s^{-1}).

Models	Regression model	R^2
Model I	Y= 3697.6 – 136.6 SR	0.39
Model II	Y = 2523.4 – 160.0 SR + 50.8 T_{max}	0.42
Model III	Y = 3039.3 – 158.2 SR + 50.8 T_{max} – 252.4 WS	0.45
Model IV	Y = 122412 – 155.7 T_{max} – 163.3 WS – 978.0 RF	0.49

by AICRP made a significant impact on horizontal spread of pigeonpea varieties in selected villages.

Relationship between yield and weather during study period

The rainfall varied between 305 to 867 mm, minimum temperature varied between 19.5 to 21.5 0C, maximum temperature varied between 28.9 to 33.4 0C, average relative humidity (58.1 to 78.3 %), wind speed (1.94 to 2.33 m s^{-1}), solar radiation (13.9 to 17.7 MJ m^{-2}) during 2012-20 period (Figs. 3, 4). Minimum temperature (0.192*) and relative humidity (0.225**) was positively highly significant effect on yield of pigeonpea. While, solar radiation (-0.622**) and wind speed (-0.188**) were negatively correlated with seed yield of pigeonpea (Table 5). The similar result observed by Singh *et al.* (2016). Stepwise regression analysis was performed to find out the critical weather parameters responsible for higher yield (Table 6). During the growing season, seed yield was influenced by solar radiation, maximum temperature, wind speed and rainfall which accounted for 49% variation in seed yield of pigeonpea crop.

CONCLUSIONS

The findings of FLD showed that the yield of pigeonpea can be enhanced by 24.8 to 38.9 % with the use of improved technologies in Warangal District. The FLDs showed a great impact showing the overall trend in adoption of production technologies which increased by 349.1% in selected villages. The local varieties were replaced by improved cultivars like WRG-65, WRG-53, WRG-27, ICP-8863, ICPL-87119 and LRG-41 on a large scale in demonstrated area. The FLDs made a positive and significant impact on yield of pigeonpea by 31.6%. Higher benefit cost ratio has confirmed the economic viability of the demonstration and the adoption of improved technologies by the farmers. The participated farmers in FLDs act as source of information and improved seeds for larger spreading of the improved varieties of pigeonpea for other adjoining areas of farmers. The improved technologies are very important for increasing the yield of pigeonpea crop. Thus frontline demonstrations play a key role in faster familiarity and spread of the improved technologies by improving the productivity, low cost of production, reducing the yield gaps and increasing the economic returns making the technology more viable and adoptable.

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