Original Research Article

Evaluation of Growth and Yield parameters of six different rice fallow crops under zero-till system with limited irrigation

ABSTRACT

A field experiment was conducted in sandy loam soils to study the Growth and Yield parameters of six different crops with limited number irrigations under zero-till system in rice fallows during *rabi*, 2021-22 at Agricultural College Farm, Naira. The experiment was laid out in split-plot design, replicated thrice with three irrigation levels viz., two irrigations (I_1), three irrigations (I_2) and four irrigations (I_3) assigned to main plots and six fallow crops viz., Maize (C_1), Sorghum (C_2), Fingermillet (C_3), Mustard (C_4), Sunhemp (C_5) and Blackgram (C_6) assigned to sub plots. With regard to number of irrigations, drymatter production at harvest, seed yield, Blackgram equivalent yield, stover yield, were recorded progressively higher with four irrigations (I_3) and were decreased gradually and significantly with reduction in number of irrigations to two (I_1). Pertaining to six fallow crops, the drymatter production, seed yield, and stover yield recorded, was significantly superior and highest in Maize (C_1) while recorded lowest in Mustard (C_4). With regard to the interaction effect with number of irrigations and six fallow crops was significant and statistically measurable. The highest drymatter production, seed yield, and stover/haulm yield was recorded in Maize (C_1) with four irrigations (I_3) and these parameters were found to be lowest in Mustard (C_4) with two irrigations (I_1).

Keywords: Limited irrigation, Rice fallows, Zero-till system.

INTRODUCTION

Global demand for grain crops is expected to grow rapidly in the coming decades. Upscaling system productivity and to ensure country's food security, sustainable intensification of traditional cropping systems is indispensable (FAO, 2017). Rice (*Oryza sativa* L.) fallow (~14 million ha) is a typical monocrop rice-based system of south Asia (particularly India including Andhra Pradesh), presently gaining larger attention as promising means for sustainable intensification. Rice is grown during *kharif* which is normally followed by a fallow during the *rabi* (November- February). Efficient utilization of these fallow lands may increase the productivity and make the whole system sustainable (Riton Chowdhury et al., 2020). Soil condition and climatic situation clearly suggest that short duration crop can easily be fit in that situation. The resources present in the rice fallows clearly giving an opportunity to introduce different crops into the situation. It will surely be an excellent inclusion, if the location specific constraints are been managed efficiently. Then those unutilized lands can be efficiently converted into productive one. It will not only increase the production of the system but also strengthen the economic condition of the farmers, improve the soil. Therefore, the present investigation was carried out in rice-fallows under zero-tillage conditions in achieving the highest productivity in the county. Overall productivity and sustainability of the system will improve with inclusion of low input crops in rice-fallows (Kumar et al., 2018). Among different fallow crops, Maize reported the highest grain yield (5.88 t/ha) with 4 irrigations provided at four leaf stage + eight leaf stage + tasselling stage + grain filling stage and which was statistically similar to 3 irrigations provided at Four leaf stage + tasselling stage + grain filling stage (Kobir et al., 2019). Higher equivalent yield in Maize (6320 kg ha^{-1}), Sorghum (6992 kg ha^{-1}) and Bajra (2768 kg ha^{-1}) were recorded under irrigation scheduled at vegetative, flowering and grain filling stages

(Three irrigations) as reported by (Nazma et al., 2019). Similarly, in Mustard (Alamin *et al.,* 2019) observed tallest plants, maximum number of branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1}and the highest seed yield (1.05 t ha^{-1}) with three irrigations in Mustard.

MATERIALS AND METHODS

A field experiment was conducted at Agriculture College Farm, Naira of Acharya N. G. Ranga Agricultural University located at North Coastal Zone of Andhra Pradesh during *Rabi*, 2021-2022. The soil of the experimental site was sandy loam in texture, with pH 7.2, organic carbon 0.38 %, available nitrogen 225 kg ha-1, available P_2O_5 31 kg ha-1 and available K_2O 275 kg ha-1. The weather conditions during the crop growth period were normal.

The experiment was laid out in a split plot design, replicated thrice with three irrigation levels *viz.,* two irrigations (I_1), three irrigations (I_2) and four irrigations (I_3) assigned to main plots and six different crops *viz.,* Maize (C_1), Sorghum (C_2), Fingermillet (C_3), Mustard (C_4), Sunhemp (C_5) and Blackgram (C_6) assigned to sub plots.

The cultivars used for the experiment in six crops were Maize (*Zea mays*) hybrid is DKC 9150, Sorghum (*Sorghum bicolor*) hybrid is CSH 16, Finger millet (*Eleusine coracana*) variety is Sri Chaitanya, Mustard (*Brassica nigra*) variety is Pusa Mustard 28, Sunhemp (*Crotalaria juncea L*.) variety is Shailesh (SH-4), and Blackgram (*Vigna mungo*) variety is LBG 787 (Tulasi), were procured for sowing. Seeds of maize and sorghum were dibbled at recommended spacing 60x20 cm and 45x15 cm. Finger millet, mustard, sunhemp and blackgram were broadcasted uniformly. Sowings were done at 14th December, 2021 in residual soil moisture after the harvest of paddy crop.

To maintain optimum plant population, gap filling was done at 15 DAS and thinning was done at 20 DAS. Two hand weedings were carried out at 20 and 40 DAS to keep the plots free from weeds. Fertilizer was applied as per the recommended doses to respective crops. The crops were grown on residual soil moisture up to first irrigation and there after irrigations were given as per the treatments.

The initial and final plant population in the net plot were counted at 15 DAS after gap filling as initial plant population and final plant population was recorded just before the harvest of the crop and expressed as no. m-2.

The days to 50% flowering were recorded as the number of days taken from sowing to 50% flowering was determined as and when 50% of the plants in each plot showed anthesis and expressed as number of days to 50% flowering. The days to maturity was recorded as the number of days taken by the crop from date of sowing to the stage to attain physiological maturity was recorded treatment wise and expressed as days to maturity.

Drymatter Production was recorded as considering five successive plants, and plants were sampled at 30, 60 DAS and maturity to record drymatter production. Root portion was removed and the samples were shade dried for some days followed by hot-air oven drying at 60˚C till a constant weight was obtained. The dry weights of the plants were taken and averaged and expressed in kg ha-1.

The Grain yield of different crops were recorded by taking the sun dried cobs of maize, earheads of sorghum and finger millet and pods of mustard, sunhemp and blackgram from net plot area were threshed, cleaned and weight of the grain was recorded as grain yield net plot area-1. Grain yield ha-1 was worked out and expressed in kg ha-1.

Stover yield of different crops were recorded after threshing, the plants from six different crops were taken from the net plot area were dried and weight was recorded. Stover yield ha^{-1} was worked out and expressed in kg ha^{-1}.

Statistical analysis was done by taking the data and recorded on various parameters of crop during the course of investigation was statistically analyzed following the analysis of variance for split plot design analyzed by following the method of Fisher´s method of analysis of variance with factorial

concept as suggested by Panse and Sukhatme (1985). Statistical significance was tested with F-test at 5 per cent level of probability and Critical Difference (CD) was calculated wherever F-test was found significant.

RESULTS AND DISCUSSION

Initial and final plant population of six fallow crops

Data pertaining to initial and final plant population was recorded non-significant with limited number of irrigations in Table 1. There was no significant difference in initial and final plant population in six fallow crops. The plant population was optimum during the experiment. Sufficient amount of soil moisture is very crucial at the time of sowing for rice fallow crops and in case of excess soil moisture and less moisture in the soil will reduce the germination percentage there by reducing the optimum plant population.

Days to 50 per cent flowering and days to maturity of six fallow crops

Data regarding on days to 50 per cent flowering and maturity with limited number of irrigations to six fallow crops were presented in Table 2. Perusal of the data revealed that days to 50 per cent flowering and maturity did not vary significantly with number of irrigations and with six fallow crops as well as their interaction effect.

Drymatter Production at harvest of six fallow crops

Data pertaining to Drymatter production for six different fallow crops at harvest were presented in Table 3. Significant difference in drymatter production at harvest was observed with different number of irrigations in six fallow crops.

At harvest the highest drymatter production was progressively increased with four irrigations (8053 kg ha^{-1}) and drymatter production decreased significantly and gradually with reduction in number of irrigations and recorded minimum values with two irrigations (6675 kg ha^{-1}). Among six fallow crops Maize recorded significantly higher drymatter production (20374 kg ha^{-1}) and Mustard recorded the lowest drymatter production (1668 kg ha^{-1}).

Interaction effect on drymatter production was significant between number of irrigations and six fallow crops. The highest drymatter production at harvest was significantly highest in Maize with four irrigations (23043 kg ha^{-1}) lowest drymatter production was recorded in Mustard with two irrigations (1476 kg ha^{-1}) which was however, on par with three irrigations (1666 kg ha^{-1}).

With respect to number of irrigations, drymatter accumulation by crops was superior with four irrigations, as the irrigations were provided at critical stages of crop growth for different crops. The luxuriant vegetative growth due to ample and adequate availability of moisture and nutrients might have direct impact on drymatter accumulation in crops. Drymatter production with two and three irrigations in different crops was low due to absence of irrigation at critical stages of crop growth. The highest percentage of dry matter was initially observed to be assigned to leaves and stem and from the reproductive phase as the highest drymatter was conferred to the reproductive organs, because after flowering there is intense demand for carbohydrates and nutrients for grain filling. Among six fallow crops Maize followed by Sorghum recorded significantly higher dry matter production and Mustard followed by Blackgram recorded the lowest drymatter production due to the variation between different crops in terms of drymatter accrual. The present findings are in conformity with those reported by Biswakarma *et al*. (2020), Nazma *et al*. (2019) and Maruthupandi *et al*. (2017).

Seed yield (kg ha-1) of six fallow crops with limited number of irrigations

The data pertaining to seed yield of six fallow crops with limited number of irrigations were presented in the Table 4. The seed yield of different crops with number of irrigations was observed as significant. Among six fallow crops there was significant difference recorded pertaining to seed yield and as well as their interaction effect also.

The seed yield was progressively increased with four irrigations (3281 kg ha^{-1}) and seed yield was decreased significantly and gradually with reduction in number of irrigations and recorded minimum values with two irrigations (2342 kg ha^{-1}). Among six different crops the highest seed yield was recorded with Maize crop (7517 kg ha^{-1}) followed by Sorghum and the lowest was recorded with Mustard crop (453.6 kg ha^{-1}).

With regard to interaction effect between number of irrigations and six different crops on seed yield was significant. The highest seed yield (10011 kg ha^{-1}) was recorded with four irrigations in Maize crop and lowest seed yield (372 kg ha^{-1}) was observed with two irrigations in Mustard crop which was however, on par with four irrigations (464 kg ha^{-1}).

Crops like Maize, Sorghum, Fingermillet and Sunhemp requires four irrigations for better growth and development of plant physically and physiologically which directly impacts the final yield of crop. Timely supply of moisture at critical stages of crop growth might have elevated the growth and yield structure of these crops which in turn enhanced the flow of food materials from source to sink and finally reflected as higher yields. Mustard crop records better yield with three irrigations provided at critical stages of crop growth than two and four irrigations. Rice fallow Blackgram shows significantly higher yields with two irrigations when given at most critical stages in flowering and pod formation stages. Crops like Maize, Sorghum, Fingermillet and Sunhemp requires four irrigations for better growth and development of plant physically and physiologically which directly impacts the final yield of crop. Timely supply of moisture at critical stages of crop growth might have elevated the growth and yield structure of these crops which in turn enhanced the flow of food materials from source to sink and finally reflected as higher yields. Mustard crop records better yield with three irrigations provided at critical stages of crop growth than two and four irrigations. Rice fallow Blackgram shows significantly higher yields with two irrigations when given at most critical stages in flowering and pod formation stages. Optimum maintenance of soil moisture with limited number of irrigations at critical crop growth stages is the key to attain higher yields. The results obtained in the present investigation also corroborating with the earlier findings of Piri *et al*. (2020), Alamin *et al*. (2019), Kobir *et al*. (2019) and Nazma *et al.* (2019).

Stover/haulm yield (kg ha^{-1}) of six fallow crops with limited number of irrigations

The stover/haulm yield with number of irrigations in six fallow crops was presented in the Table 5. There was significant difference with number of irrigations. Among six fallow crops the stover/haulm yield varies significantly. Interaction effect among these two is statistically measurable and significant.

The stover/haulm yield recoded progressively highest with four irrigations (6271 kg ha^{-1}) and decreased significantly and gradually with reduction in number of irrigations and recorded lowest with two irrigations (4895 kg ha^{-1}). As regards with six fallow crops the stover yield was maximum with Maize (12751 kg ha^{-1}) crop and minimum with Mustard crop (1217 kg ha^{-1}).

The interaction effect between number of irrigations and six fallow crops on stover/haulm yield reported as significant. The maximum stover/haulm yield was recorded with four irrigations in Maize crop (15044 kg ha^{-1}) and the minimum stover yield was recorded with two irrigations in Mustard crop (1067 kg ha^{-1}) which was however, on par with four irrigations (1246 kg ha^{-1}). Vegetative growth had direct impact on stover yield of different crops. Luxuriant vegetative growth results in more stover yield

and the vegetative growth will be attained by maintaining sufficient amounts of soil moisture at crop critical growth stages and with sufficient nutrients in required quantities.

Crops providing with better management practices at initial and critical stages will have prominent impact on stover yield at the time of crop maturity. Maintenance of sufficient soil moisture at critical stages of crop growth stages was the pre-requisite to attain higher yields. Stover yield was observed maximum at four irrigations in crops like Maize, Sorghum, Fingermillet and Sunhemp. Higher stover yields were attained in Blackgram with two irrigations at flowering and pod formation stages which are very critical and three irrigations in Mustard at seedling, flowering and pod formation stages which are critical stages. The present findings are in conformity with those reported by Pradhan *et al.* (2021), Kavita *et al*. (2017) and Binoy Chhetri and Sinha (2017).

CONCLUSION

From the above results it can be concluded that considering the drymatter, seed yield and stover yield, maize followed by sorghum and sunhemp were the best options when four irrigations were available.

Sorghum followed by maize and fingermillet were the good options when irrigations were limited to two to three under rice fallows.

REFERENCES

Alamin Md, Rasal Monir Md, Sumya Fatima, Kamrun Nahar, Kamal Uddin Ahamed. Effect of sowing time and irrigation frequency on growth and yield of mustard (*Brassica napus* L.). 2019;4(8):1-11.

Binoy Chhetri, Sinha AC. Growth and development of maize (*Zea mays* L.) in response to different moisture conservation and integrated nutrient management practices under rainfed condition. Journal of Pharmacognosy and Phytochemistry. 2017;6(6):1696-1701.

Biswakarma N, Pooniya V, Zhiipao RR. Assessing productivity and profitability of maize (*Zea mays*) under conservation tillage and nutrient management. Indian Journal of Agronomy. 2020,65(3): 368-371.

FAO. The future of food and agriculture – Trends and challenges. Rome. 2017.

Kavita K, Dass A, Sudhishri S, Ramanjit K, Rani A. Yield components, yield and nutrient uptake pattern in maize (*Zea mays*) under varying irrigation and nitrogen levels. Indian Journal of Agronomy. 2017,62:104-107.

Kobir, Md., Rashedur Rahman, Md., Mominul Islam, A.K.M., Suchana Pual, Monirul Islam, Md., Nasirul Farid, Md and Pradip Hajong. 2019. Yield performance of some Maize varieties as influenced by

irrigation management at different Growth stages. *Research in Agriculture, Livestock and Fisheries Journal,* 6(1): 57-67.

Kumar, N., Yadav, A., Singh, S and Yadav, S.L. 2018. Growing pulses in rice fallow: Ensuring nutritional security in India. *Conservation Agriculture for Advancing Food Security in Changing Climate*, 1: 107-122.

Maruthupandi, K and Veeramani, A. 2017. Effect of methods and time of sowing on growth indices in rice fallow blackgram (*Phaseolus mungo* L.) under machine transplanted rice system. *International Journal of Current Microbiology and Applied Sciences,* 6(11): 2738-2744.

Malla Reddy, M., Padmaja, B and Vishnu Vardhan Reddy, D. 2013. Production potential and economics of different crops in rice fallow under no till condition in Telangana region of Andhra Pradesh. *The Andhra Agriculture Journal,* 60(1): 11-16.

Nazma, S., Lakshmi, N.V., Chandrashekar, K., Lakshmi, G.V and Prathibha Sree, S. 2019. Influence of water management practices on yield and moisture use efficiency of different millet crops under rice fallow. *The Andhra Agriculture Journal,* 66(3): 433-435.

Panse, V.G and Sukhatme, P.V. 1978. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, pp. 361.

Parameswari, Y.S., Srinivas, A and Ram Prakash, T. 2017. Productivity and economics of rice (*Oryza sativa*) zero till maize (*Zea mays*) as affected by rice establishment methods and weed management practices. *International Journal of Current Microbiology and Applied Sciences.* 6(10): 945-952.

Piri Issa, Mohsen Moussavi Nik, Abolfazl Tavassoli, Fatemeh Rastegaripour and Mahdi Babaeian. 2020. Effect of irrigation frequency and application levels of sulphur fertilizer on water use efficiency and yield of Indian mustard (*Brassica juncea*). *International Journal of Irrigation and Water Management,* 7(8): 1- 9.

Pradhan, Amaresh, Meena, S.L and Behera, U.K. 2021. Growth, yield and nutrient uptake of maize (*Zea mays*) as influenced by tillage and potassium management under conservation agriculture. *Indian Journal of Agronomy*, 63(3): 383-387.

Riton Chowdhury, Md., Subhaprada Dash, Koushik Sar, J.M.L and Gulati. 2020. Pulses in Rice Fallow: A Way towards Achieving Nutritional Security. *Agricultural Reviews*, 41: 264-271.

DISCLOSURE STATEMENT

"The author(s) declare(s) no known conflict of interests that could have appeared to influence the work reported in this paper."

Table 1: Initial and final plant population (no m-2) of six fallow crops with limited number of irrigations

TREATMENTS	Initial plant population	Final plant population
Main plots : No of Irrigations		
M_1: Two Irrigations	27	25
M_2: Three Irrigations	27	26
M_3: Four Irrigations	28	27
SEm±	0.6	0.6
CD (P=0.05)	NS	NS
CV (%)	9.1	9.6
Sub plots : Different crops		
C_1: Maize	9	8
C_2: Sorghum	13	12
C_3: Fingermillet	54	52
C_4: Mustard	19	18
C_5: Sunhemp	33	31
C_6: Blackgram	36	35
SEm±	0.5	0.5
CD (P=0.05)	NS	NS

CV (%)	5.1	5.4
Interaction		
SEm±	0.8	0.8
CD (P=0.05)	NS	NS

Table 2: Days to 50 % flowering and days to maturity of six fallow crops with limited number of irrigations

TREATMENTS	Days to 50 % flowering	Days to maturity
Main plots : No of Irrigations		
M_1: Two Irrigations	54.00	96.90
M_2: Three Irrigations	52.06	97.00
M_3: Four Irrigations	53.17	97.11
SEm±	1.12	1.77
CD (P=0.05)	NS	NS
CV (%)	8.8	7.7
Sub plots : Different crops		
C_1: Maize	62.89	114.3
C_2: Sorghum	67.11	112.4
C_3: Fingermillet	81.11	106.6
C_4: Mustard	35.89	77.22
C_5: Sunhemp	38.11	97.11
C_6: Blackgram	34.56	74.33
SEm±	0.97	1.79
CD (P=0.05)	NS	NS
CV (%)	5.4	5.5
Interaction		
SEm±	1.67	3.10
CD (P=0.05)	NS	NS

Table 3: Interaction effect of Drymatter Production (kg ha-1) at harvest of six fallow crops with limited number of irrigations

Treatments	DMP at harvest			
	M_1: Two Irrigations	M_2: Three Irrigations	M_3: Four Irrigations	Mean
C_1: Maize	18024	20055	23043	20374
C_2: Sorghum	9643	10609	12109	10787
C_3: Fingermillet	4017	4115	4376	4169
C_4: Mustard	1476	1863	1666	1668
C_5: Sunhemp	3617	4129	4229	3990
C_6: Blackgram	3275	3097	2902	3091
Mean	6675	7311	8053	7346

	SEm±	CD (p = 0.05)	CV (%)
Six different crops (S)	147	425	6.01
Number of Irrigations (M)	122	480	7.06
S at M	255	737	--
M at S	263	780	--

Table 4: Interaction effect of Seed yield (kg ha-1) of six fallow crops with limited number of irrigations

Treatments	Seed yield			
	M_1: Two Irrigations	M_2: Three Irrigations	M_3: Four Irrigations	Mean
C_1: Maize	5403	7136	10011	7517

C_2: Sorghum	5643	5820	6112	5858
C_3: Fingermillet	1199	1489	1683	1457
C_4: Mustard	372	525	464	454
C_5: Sunhemp	796	863	935	865
C_6: Blackgram	639	573	482	565
Mean	2342	2734	3281	2786

	SEm±	**CD (p = 0.05)**	**CV (%)**
Six different crops (S)	59	171	6.3
Number of Irrigations (M)	58	229	8.8
S at M	103	296	--
M at S	110	330	--

Table 5: Interaction effect of Stover/haulm yield (kg ha-1) of six fallow crops with limited number of irrigations

Treatments	**Stover/haulm yield**			
	M_1: Two Irrigations	**M_2: Three Irrigations**	**M_3: Four Irrigations**	**Mean**
C_1: Maize	10630	12581	15044	12751
C_2: Sorghum	10583	11408	12409	11467
C_3: Fingermillet	1989	2355	2684	2342
C_4: Mustard	1067	1339	1246	1217

C_5: Sunhemp	3010	3734	4330	3691
C_6: Blackgram	2092	1944	1918	1985
Mean	4895	5560	6271	5575

	SEm±	**CD (p = 0.05)**	**CV (%)**
Six different crops (S)	186	536	9.9
Number of Irrigations (M)	145	571	11
S at M	321	928	--
M at S	327	968	--

ETHICAL STATEMENT

"Not applicable".

COPYRIGHT STATEMENT

"The article does not contain any copyrights protected material".

LIST OF ABBREVIATION

"Not applicable".