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STUDY ON EXPORT COMPETITIVENESS OF ONION FROM INDIA

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ABSTRACT

India is the second largest onion growing country in the world. Globally, the demand for Indian onion is increasing day by day. Fresh onions occupy first place in exports from India under fresh fruits and vegetables category with 11.50 million tonnes exports worth of ₹ 2,320.70 crores during the year 2019-20. Export competitiveness was estimated by calculating the Nominal protection coefficients (NPC) using secondary data for a period from 2017 to 2019. The results revealed that onion exports to Bangladesh have moderate competitive advantage during the study period.

KEYWORDS: Export competitiveness, Nominal Protection Coefficients and onion exports.

INTRODUCTION

Agriculture sector occupies an important role in development of India economy. India is currently ranked tenth amongst the major exporters globally as per WTO trade data for 2019. India's share in global exports of agriculture products has increased from 1.7 per cent a few years ago, to 2.1 per cent in 2019.

Production and trade of agricultural commodities are crucial to the economic progress of the developing countries like India since agriculture continues to be the predominant livelihood source for large share of its population. Because of globalization the economic reforms came into existence and international boundaries open up for our country for providing opportunity for sale. India is a traditional exporter of fresh onion. Immediately after Independence in 1947, in 1951-52 the country was exporting over 5,000 tones of onion per year. Exports of onion started expanding rapidly during the '60s. There are, however, apparent wide fluctuations in exports from year to year. India has experienced robust growth in export of fresh and processed agricultural products over the last decade. Amongst the fresh fruits and vegetables exported by India, fresh onion fetching the highest export revenue. This underlines the importance of onion in India's export exchequer.

Onion is mainly grown in Asia, Africa and north America and the major onion producing countries were China, India and United states of America. In 2019, the global area under onion was reported by FAO to be 6.32 million hectares, with a production of 99.52 million tonnes. India ranks first in the world accounting for the world area, planted to onion. Globally, the country occupies the second position, after China, in onion production with a production share of 22.83 per cent. In this context the present study was made to estimate the growth rate of onion exports from India and export competitiveness of onion from India.

MATERIAL AND METHODS

To study the growth rates of the onion exports from India, quantity and value of the exports for a period of 25 years *i.e.* from 1995-96 to 2019-20 were collected from (APEDA) Agricultural and Processed Food Products Export Development Authority. Growth of any economic variable signifies its past performance. Growth in quantity and value of onion exports were analysed by using the exponential growth function of the following form,

$$Y = ab^t$$

where,

Y = Dependent variable *i.e.,* quantity, value and unit value of onion exports

a = Intercept or constant

b = Trend coefficient (slope)

t = Time variable (Years)

The function takes the form of a linear equation in a logarithmic and becomes log-linear as shown below:

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$$\text{Ln Y} = \text{Ln a} + \text{t Ln b} + \mu$$

Where 'Ln Y' is natural logarithm of Y, 'Ln a' and 'Ln b' are similarly defined.

The compound growth rate was then computed by using the relationship given as;

Compound Growth Rate (CGR) = [Antilog (b) – 1] * 100

The significance of the regression coefficient (Ln b) was tested by t ratio.

Further the instability in onion exports were calculated by using coefficient of variation. The coefficient of variation (CV) was calculated by using the following formula;

$$\text{CV} = \frac{\text{Standard deviation}(\sigma)}{\text{Mean}\ (\bar{\text{X}})} \times 100$$

Traditionally, price is one of the most important indicator of competition as it is a reflection of consumer appreciation of quality and indirect indicator of relative efficiency of the production process. Hence a price based measure like Nominal Protection Coefficient (NPC) has been accepted as a standard measure of competitiveness. Nominal protection coefficient is a direct measure of comparative advantage enjoyed by a commodity in the context of free trade. Although NPC measures only the deviation of domestic prices relative to world prices, the conclusion drawn regarding the policy environment facing agricultural production activity are essentially the same as those drawn from any other robust calculations. The coefficients shed light whether the country has comparative advantage in the production of that commodity or not. NPCs of Indian onion export were estimated in order to examine its export competitiveness in the world market. NPC is defined as the ratio of the domestic price to the world reference price of the commodity under consideration.

Symbolically, NPC = Pd / Pe

where,

NPC = Nominal protection coefficient.

Pd = Domestic price of onion adjusted for handling/marketing charges and transportation cost.

Pe = Export price or FOB price/ what the farmer would have received in the context of free trade.

A decision criterion is, if NPC is less than one, then the commodity is export competitive (under exportable hypothesis, and it is worth exporting). If NPC is greater than one, the commodity is not export competitive (not a good export product). NPC helps in measuring the divergence of domestic price from the international price and thus determine the degree of protection (incentive) or dis-protection (disincentive) of the commodity in question.

To calculate the NPCs for the present study, Wholesale prices were obtained from Nasik market. FOB prices were calculated by adding wholesale price, transportation charges, marketing margin of exporter, port clearance and handling charges, certification charges. Landed price was calculated by adding FOB price, freight charges and insurance premium. CIF prices were obtained by dividing landed cost with exchange rates. NPCs were calculated by dividing CIF prices with reference prices of Bangladesh. As Bangladesh was the major importer of Indian Onion, NPC's were calculated with reference to Bangladesh. Reference prices of Bangladesh were collected from the year books of Agricultural statistics of Bangladesh.

RESULTS AND DISCUSSION

Onion Exports from India

From the Table 1 it was revealed that the production of onion in India was increased from 4080000 MT to 22819000 MT for a period from 1995-96 to 2019-20. The growth in domestic onion production was calculated by using exponential form and the CAGR was 9.13 which indicated that there was a positive growth in production of onion in the country. Export of onion in terms of quantity and value was increased from 350989.17 MT to 1114828.57 MT and 230.74 crores to 2320.70 crores respectively for the same period. Further growth in Indian onion exports in terms of quantity and value was estimated to be 8.54 and 14.60 per cent. Share of Indian onion exports in national onion production was estimated and the results indicated that the share was 8.60 in 1995-96 and 4.89 in 2019-20. The growth in share percentage was -0.54. World onion exports during 1995-96 was 4505829 MT and in 2019-20 it was 13919105 MT and the growth percentage was 5.43 per cent. Share of Indian onion

Table 1. Onion export from India, its share (%) to domestic production and world export

Year	Production (MT)	Export (MT)	Value (₹ Crores)	Share in domestic production (%)	World export of onion (MT)	Share in worlds export (%)
1995-96	4080000	350989.17	230.74	8.60	4505829	7.79
1996-97	4180000	427011.78	265.21	10.22	4472245	9.55
1997-98	3200000	333348.95	202.46	10.42	4127152	8.08
1998-99	5331900	215693.63	176.06	4.05	4815553	4.48
1999-00	4899500	260475.27	202.72	5.32	4705228	5.54
2000-01	4721100	343253.69	276.19	7.27	4392935	7.81
2001-02	5252100	441849.60	332.42	8.41	4823937	9.16
2002-03	4209500	588449.75	361.58	13.98	5531896	10.64
2003-04	6267600	859938.75	715.89	13.72	6884427	12.49
2004-05	7760600	870196.86	644.14	11.21	6946240	12.53
2005-06	9432500	959276.32	708.17	10.17	7305251	13.13
2006-07	10847000	1377005.03	1,163.30	12.69	8261072	16.67
2007-08	13900000	1008413.57	1,035.74	7.25	8588665	11.74
2008-09	13565000	1670160.28	1,827.52	12.31	9163738	18.23
2009-10	12158800	1651968.22	2,319.44	13.59	9276257	17.81
2010-11	15118000	1164030.92	1779.26	7.70	10773285	10.80
2011-12	17511090	1290938.98	1723.03	7.37	10770200	11.99
2012-13	16813000	1616354.21	1966.67	9.61	9865470	16.38
2013-14	19299000	1461521.93	3169.63	7.57	11392754	12.83
2014-15	19401680	1223338.36	2300.57	6.31	11017488	11.10
2015-16	18927000	1360884.87	3097.19	7.19	11216302	12.13
2016-17	20931000	2371439.86	3106.08	11.33	11792762	20.11
2017-18	22427000	1543379.60	3088.79	6.88	12147719	12.71
2018-19	23262000	2122091.22	3468.83	9.12	12343606	17.19
2019-20	22819000	1114828.57	2320.70	4.89	13919105	8.01
Growth (%)	9.13	8.54	14.60	-0.54	5.43	2.95
C.V	56.99	56.04	78.42	31.05	36.87	33.81

Source: Production, World Export data from FAOSTAT and Export data from APEDA exports in world onion exports were calculated and the results indicated that the percentage was 7.79 in 1995-96 and 8.01 in 2019-20 and CAGR was 2.95 per cent.

It confirms the increase in the exports on par with the increase in production but the share of Indian onion exports in domestic production over the period was reducing which indicated the scope for further increasing the Indian onion exports, it also confirmed the increased preference of Indian onion in the global market. A close look at the results revealed that share of Indian onion exports in world exports was increasing from 1995-96 to 2018-19, but it was drastically reduced in 2019-20 the reason was ban in the exports of onion from September 14th 2019 to January 1st 2020 after a bad crop crimped output causing domestic onion prices to show signs of firming up.

The results were in line with the result of Kulkarni *et al.,* (2012) and Ajaruddin and Maman (2020).

EXPORT COMPETITIVENESS OF ONION UNDER EXPORTABLE HYPOTHESIS (2017, 2018 and 2019)

The competitiveness of Indian onion was examined using nominal protection coefficient (NPC). Nominal Protection Coefficients were computed to determine the extent of competitive advantage enjoyed by the commodity in the context of free trade. The coefficients had highlight on whether a country has comparative advantage in the export of that commodity in the free trade scenario or not (Guledgudda *et al.,* 2014).

The NPC value of less than unity indicates global competitiveness of the commodity under consideration, the NPC value less than 0.5 denotes high competitiveness and from 0.5 to 1.0 indicates moderate competitiveness (Jayesh, 2001). NPC's were estimated to Bangladesh as it is the major importer under exportable hypothesis for a period of three years (2017 to 2019) as discussed below.

The NPC calculated by taking the wholesale prices of onion which were considered from the Nasik market because it is having the major exports of onion from the nation to major destination Bangladesh. The wholesale prices from (Nasik) India were calculated by taking the average monthly wholesale prices of onion from AGMARKNET. Table 2.1 shows estimated NPCs of onion exports to Bangladesh over a period of three years. The NPC observed as 0.81 in 2017, 0.88 in 2018 and 0.64 in 2019. These figures revealed that Onion exports to Bangladesh have moderate competitive advantage during the study period. Further, the average NPC value (0.78) is close to one which indicates that the competitiveness was low during the study period.

Table 2. Nominal protection coefficients of Indian onion to Bangladesh (2017 to 2019)

S. No.	Particulars	Units	2017	2018	2019
1.	Wholesale price in Nashik market	₹/Qtl	1303.83	1824.72	1723.50
2.	Transportation charges	₹/Qtl	160.00	190.00	200.00
3.	Market margin(5%) of the whole sale price	₹/Qtl	59.22	53.34	94.15
4.	Port clearing and handling charges	₹/Qtl	100.00	100.00	100.00
5.	Fumigation charges	₹/Qtl	100.00	100.00	100.00
6.	Certification charges	₹/Qtl	0.00	0.00	0.00
7.	FOB prices	₹/Qtl	1723.05	2268.06	2217.65
8.	Freight charges from India to Bangladesh	₹/Qtl	300.00	350.00	400.00
9.	Insurance(2%)	₹/Qtl	23.68	21.33	37.65
10.	Landed price	₹/Qtl	2046.73	2639.39	2655.30
11.	Exchange rate	1BDT = ₹	0.873	0.814	0.834
12.	CIF price	BDT/Qtl	2344.48	3242.49	3183.81
13.	Reference price of Bangladesh	BDT/Qtl	2899.00	3677.00	4943
14.	NPC		**0.81**	**0.88**	**0.64**

Hyma *et al.* (2003) reported that the average value of onion calculated at SER for the financial years from 1996-97 to 1999-2000 was 0.80 indicating the moderate export competitive nature of Indian exports. Further, Gulati *et al.* (1994) reported average NPC at SER for onion during 1986-87 to 1992-93 was 0.71. This indicates the moderate competitive advantage of Indian onion.

The results revealed that the export of onion to Bangladesh have moderate advantage and the average NPC indicated that the competitiveness was low. From time to time the government will ban the export of onion and also imposes MEP to tame domestic prices. This creates lot of instability in the export of onion as it debars traders from exporting onions. Hence an appropriate export policy should be developed. This will safeguard India's reputation in the global market as a reliable supplier. Exporting dehydrated onion in the form of powder/ flakes/ chopped slices will attracts new avenues for exporting onion. Quality assurance is the key factor for export competitiveness of dehydrated onion.

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BUYING BEHAVIOUR OF FARMERS TOWARDS PLANT GROWTH PROMOTERS IN CHITTOOR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The present study was to know the factors influencing the farmers buying behaviour towards plant growth promoters and constraints faced by farmers purchasing process in Chittoor district of Andhra Pradesh. Sample farmers were cultivating mango, tomato and chrysanthemum. Chittoor district was purposively selected as it occupies first place gross area sown in Andhra Pradesh. The analytical tools employed were percentages, Garrett's ranking technique and Likert's scale technique. Price was the major constraint while purchasing of plant growth promoters, awareness towards results of the plant growth promoters was high and not much aware of different types and brands of the plant growth promoters.

KEYWORDS: Buying behaviour, Garrett's ranking and Likert's scale

INTRODUCTION

Agriculture is the primary source of livelihood up to 58 per cent of India's population. With increasing population, demand for food and agricultural production is inevitable.

Apart from the essentials like oxygen, water, sunlight, it is the harmones that modulate the growth of individual plant parts and controls various physiological activities. The plant growth regulators are also called as plant growth harmones or phytoharmones which are either synthesized in the laboratory or produced naturally within the plant. Plant growth regulators are of two major groups one that promotes the growth and the other that retards the growth of the plants. The global market of plant growth regulators is driven by declining farming area coupled with increasing demand for organic food. The Humic acid global market is estimated to grow by CAGR of 14 percent by 2026 from 510.9 million USD in 2018. (Anonymous, 2018). Agriculture application being the largest segment with 55 percent market share. (Anonymous, 2022.) The common source of purchasing the plant growth promoters by farmers is through local dealers. Dealers not only sell to farmers but also play important role in the source of information about the products and their distribution function, also influencing the amount and type of plant growth promoters used by farmers. Buying decision is a set of many decisions which may involve a product, brand, quality, dealers, time and price. The objective was set to study the buying behaviour of farmers and constraints faced by them in purchasing plant growth promoters.

MATERIAL AND METHODS

For this study Chittoor district was purposively selected as it occupies first place gross area sown in Andhra Prades. Two mandals of Chittoor district were selected. Three villages from each mandal were identified and from each village 10 farmers were selected randomly, making a sample size of 60 farmers. A well framed schedule was developed based on objectives. Primary data was collected using personal interview method. The data was collected for the month of August and the year 2021. Secondary data required was collected from authenticated sources and other e-resources. Descriptive statistics and appropriate statistical tools like percentage analysis, Garrett's ranking, Likert's scaling were employed in the study.

RESULTS AND DISCUSSIONS

Factors influencing and constraints faced by the farmers towards plant growth regulators

For farmers major source of information about plant growth promoters were dealers. Most of the farmers prefer credit sales, if credit sales were not available, most of the farmers had switched to dealers those providing credit

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(70.00%) and if required brand is not available majority of the farmers were shifting to other brand (82.00%) and only (12.00%) of them wait for the required brand (Yeshwanth *et al.,* 2019).

Table 1. Farmer's decision during the non-availability of required plant growth promoter brand

Variable	No. of farmers	Percentage
Switch over to other dealers	42	70.00
Credit source from others	10	17.00
Reduce the quantity of application	8	13.00
Shift to other brands	53	82.00
Wait for the required brand	7	12.00
Total	**60**	**100.00**

Table 2 revealed that regarding the source of information was through dealers as farmers were not much aware of plant growth promoters, relying on dealers followed by progressive farmers, department of agriculture, company representatives, communication media, kissan call centers and cooperative societies were ranked least as there were no such provisions for farmers (Gaikwad and Jirali, 2016).

Table 3 depicted that most of the farmers were purchasing plant growth promoters from private dealers as they were getting information of plant growth promoters, followed by both the sources from private dealers and agriculture department, among them farmers highly preferring private dealers alone, agriculture department and cooperative societies alone were least ranked as they were not aware of such provisions (Yeshwanth *et al.,* 2019).

Table 2. Source of information on plant growth promoters

Particulars	Total score	Garrett's mean score	Rank
Department of agriculture	3406	56.76	3
Cooperative society	1494	24.90	7
Progressive farmers	4194	69.90	2
Kisan Call Centre	1806	30.10	6
Plant growth promoter dealers	4506	75.10	1
Communication media	2713	45.21	5
Company representatives	2874	47.90	4

Constraints faced by the farmers during plant growth promoters purchase from private dealers

Table 4 revealed that the major constraint faced by the sample farmers was high price of plant growth promoters followed by high interest on credit as most of the farmers in the study area were purchasing plant growth promoters on credit basis and dealers making it as an advantage, they imposing high price for the borrowed. The other constraints were in the order offer of adulteration, poor quality of the products, no discount during bulk purchases which was not forth coming, lack of credit availability, and non-availability of preferred brands (Dharmaraj *et al.*, 2013 and Jain *et al.,* 2017).

Awareness of farmers towards plant growth promoters

Table 5 depicts that sample farmers awareness was first ranked among the factors was effect of plant growth promoters on crops, followed by usage methods, time of usage, followed by dosage of plant growth promoters and least ranked on the awareness of different types and brands (Sreekanth, 2018).

1. Major source of information regarding plant growth promoters were dealers.

2. Majority of the plant growth promoters purchases were from private dealers on credit basis and shift over to dealer who provide credit if, credit sales were not available.

Table 3. Source of plant growth promoters purchase by sample farmers

Particulars	Total score	Garrett's mean score	Rank
From private dealers, agriculture department, cooperative society	3147	52.45	4
Only from cooperative society	1260	21.00	7
Both from private dealer and agricultural department	3630	60.50	2
Only from agriculture department	2580	43.00	5
Both from agriculture department and cooperative society	2040	34.00	6
Both from private dealers and cooperative society	3273	54.55	3
Only from private dealers	4675	77.91	1

Table 4. Constraints during the purchase of plant growth promoters from the private dealers

Particulars	Total score	Garrett's mean score	Rank
Poor quality products	3147	52.45	4
High interest on credit borrowing	3986	66.43	2
Preferred brands are not available	1260	21.00	7
High price	4714	78.56	1
Fear of adulteration	3273	54.55	3
Lack of credit availability	2193	36.55	6
No discount	2418	40.30	5

Table 5. Awareness of farmers on usage of plant growth promoters

Particulars	Completely aware		Moderately aware		Aware upto some extent		Unaware		Total Score	Mean score	Rank
	NR	S	NR	S	NR	S	NR	S			
Usage methods	22	88	23	69	11	22	4	4	183	3.05	2
Plant growth promoter dosage	12	48	37	111	9	18	2	2	179	2.98	4
Different brands of plant growth promoters	18	72	25	75	13	26	4	4	177	2.95	5
Effect of plant growth promoters on plants	26	104	16	48	16	32	2	2	186	3.10	1
Time of usage	17	68	29	87	12	24	2	2	181	3.02	3
Different types of plant growth promoters	21	84	18	54	15	30	6	6	174	2.90	6

NR : No. of respondents, S : Score

3. If required brand was not available most of them were shifting to other brands, few of them were waiting for the required brand.

4. Most of the farmers were purchasing from private dealers only, none of them were purchasing from agriculture department or cooperative society exclusively.

5. High price was the major constraint faced by the farmers during the purchase of plant growth promoters from private dealers.

6. Farmers awareness was first ranked with effect of plant growth promoter on crops. Different kinds and different types of brands were ranked fifth and sixth respectively.

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EFFECT OF IRRIGATION REGIMES AND NITROGEN LEVELS ON PHENOLOGY OF AEROBIC RICE (*Oryza sativa* L.) UNDER DRIP IRRIGATION

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ABSTRACT

A field study was conducted at S.V. Agricultural College, Tirupati during *rabi* seasons of 2019-20 and 2020-21 to study the effect of drip irrigation regimes and nitrogen levels on phenology of aerobic rice. The field experiment was laid out in split plot design with three replications by taking irrigation regimes (Drip irrigation at 1.25 Epan, 1.50 Epan, 1.75 Epan and 2.0 Epan) as main plots, and nitrogen levels (90 kg N ha^{-1}, 120 kg N ha^{-1}, 150 kg N ha^{-1} and 180 kg N ha^{-1}) as sub plots. Higher leaf area duration (LAD) was observed with drip irrigation regime of 2.0 Epan which was however comparable with drip irrigation at 1.75 Epan) at different intervals of crop growth except at 0-30 DAS interval, wherein irrigation regimes did not have significant influence on LAD. The lower LAD was observed with drip irrigation regime of 1.25 Epan at all the stages of crop growth. As regards to nitrogen levels higher LAD was observed with 180 kg N ha^{-1} which was however comparable with 150 kg N ha^{-1} at 30 DAS, and the lower value was observed with 90 kg N ha^{-1}. In the pooled mean, drip irrigation regime of 2.0 Epan and 1.75 Epan took significantly less number of days to attain 50% flowering over 1.5 Epan and 1.25 Epan. Aerobic rice supplied with 180 kg N ha^{-1} took less number of days to attain 50% flowering followed by lower doses and 90 kg N ha^{-1} took longer duration to attain 50% flowering. Number of days to maturity was non-significant due to irrigation regimes and nitrogen levels during both the years of study and in the pooled mean.

KEYWORDS: Aerobic rice, days to 50% flowering, drip irrigation regimes, leaf area duration, nitrogen levels

INTRODUCTION

Rice is the staple food for more than half of the world population and is generally grown under puddled transplanted conditions. Conventional puddled transplanted rice cultivation requires over 2000 mm of water and is labour, water, and energy expensive. Global water crisis threatens the sustainability of irrigated rice system due to reduced availability of water. Therefore, future production of rice to meet food needs of growing population has to be achieved using less resources such as land and water through more efficient production systems. In this direction, aerobic rice can drastically reduce water requirement and improve water use efficiency. Aerobic rice is grown under non-puddled, non-flooded and non-saturated soil conditions as other upland crops (Prasad, 2011). Growing aerobic rice with drip irrigation will meet water requirement of the crop as and when needed. Nitrogen fertilizer along with irrigation can increase crop yield greatly, however, response of nitrogen varies with the available soil moisture content. As stress due to moisture and nutrients results in variation in phenological parameters like LAD, days to 50% flowering and maturity, present study was conducted to know the influence of different irrigation regimes and nitrogen levels on phenology of aerobic rice.

MATERIAL AND METHODS

The experiment was conducted during two consecutive *rabi* seasons of 2019-20 and 2020-21 at wetland farm of S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soil was sandy clay loam with slightly alkaline pH, low in organic carbon, available nitrogen and phosphorus and medium in available potassium. Field experiment was laid out in split plot design with three replications. Treatments consisted of four irrigation schedules (I_1: Irrigation at 1.25 Epan, I_2: Irrigation at 1.50 Epan, I_3: Irrigation at 1.75 Epan and I_4: Irrigation at 2.0 Epan) as main plot treatments and four nitrogen levels (N_1: 75% RDN (90 kg N ha^{-1}), N_2: 100% RDN (120 kg N ha^{-1}), N_3: 125% RDN (150 kg N ha^{-1}) and 150% RDN (180 kg N ha^{-1})) as sub plot treatments. Healthy and viable seeds of NLR-34449 rice variety were sown by hand

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dibbling at the rate of two seeds per hill by maintaining spacing of 20 cm × 10 cm. Two uniform irrigations were given to all the treatments during the first 20 days of crop period for proper germination and establishment of crop. Drip irrigation was given on every alternate day based on pan evaporation (Epan) data according to the treatment requirements. Quantified water was supplied by measuring with water meter. The recommended dose of fertilizer was 120 : 60 : 40 kg NPK ha^{-1}. At the time of sowing, full quantity of phosphorus as SSP along with half dose of potassium as MOP were applied as basal. In addition, $ZnSO_4$ and $FeSO_4$ @ 25kg ha^{-1} were applied before sowing. Nitrogen fertilizer dose in different treatments was applied in three equal splits at 15 DAS, tillering and panicle initiation stages. Leaf area duration (LAD) for different crop intervals was calculated using the LAI at each sampling date. The LAD between two sampling time points was approximated according to the equation:

$$\mathrm{LAD} = \frac{(\mathrm{LAI}_1 + \mathrm{LAI}_2)}{2} \times t_2 - t_1$$

where, t_1 and t_2 are the sampling times and LAI_1 and LAI_2 are values of LAI at the sampling times t_1 and t_2, respectively.

RESULTS AND DISCUSSION

Leaf area duration

In this study, leaf area duration (LAD) tended to increase up to 90 DAS, later on declined towards harvest as a result of leaf senescence in all the treatments. Leaf area duration of aerobic rice was significantly influenced by irrigation regimes at different time intervals during crop period, except at 0-30 DAS interval, during which the variation was not statistically traceable due to similar foliar growth because of uniform application of irrigation water during the initial period of crop growth (Table 1, 2, 3 and 4 and Figure1).

At other time intervals, drip irrigation regime of 2.0 Epan recorded significantly higher LAD which was however comparable with the next higher irrigation regime of 1.75 Epan during both the years of investigation as well as in the pooled mean. This might be due to adequate photosynthesis, plant growth and leaf retention under optimum moisture conditions which is linked to a greater LAD. Water use was linearly related to green leaf area duration. Similar results of increase in leaf area duration with increase in soil moisture were reported by Winkel *et al.* (2001), Sudharani (2007) and Halli *et al.* (2021) in bajra, baby corn and maize, respectively. Whereas, lower LAD was noticed with drip irrigation scheduled at 1.25 Epan due to moisture stress which resulted in accelerated leaf senescence. LAD was correlated with relative leaf water content.

Among the different nitrogen levels, 180 kg N ha^{-1} registered higher LAD at 30-60 DAS, 60-90 DAS and 90 DAS-harvest intervals during both the years of study and in the pooled mean, which was significantly superior to that of 150, 120 and 90 kg N ha^{-1}. Whereas at 30 DAS, it was comparable with the application of 150 kg N ha^{-1}. Increased dose of Nitrogen from 90 to 180 kg N ha^{-1} resulted in an increase in leaf area duration which might be due to enhanced tiller growth, production of higher vegetative biomass and higher LAI at higher nitrogen doses. Similar findings were reported by Sainio *et al.* (1997) and Xiaolong *et al.* (2017).

With regard to interaction, scheduling drip irrigation at 2.0 Epan in combination with 180 kg N ha^{-1} resulted in higher LAD followed by 1.75 Epan in combination with 180 kg N ha^{-1}. Higher leaf area duration in these treatments might be due to supply of adequate nitrogen under optimum soil moisture conditions facilitating production of higher number of tillers and photosynthetic leaf area. Whereas, the lower LAD was registered with 1.25 Epan along with 90 kg N ha^{-1}.

Days to 50% flowering

Number of days to attain 50% flowering was significantly influenced by nitrogen levels during both the years of study and in the pooled mean, but it was influenced by irrigation regimes only in the pooled mean, while the interaction was not statistically traceable (Table 5 and Figure 2).

In the pooled mean, early flowering was observed with drip irrigation regimes of 2.0 Epan and 1.75 Epan which recorded significantly less number of days to attain 50 % flowering over 1.5 Epan. Whereas, delayed flowering was observed with the lower irrigation regime *i.e.,* 1.25 Epan. Early flowering under higher drip irrigation regimes might be due to favourable soil moisture status for better growth of the crop, which favoured early cessation of vegetative growth leading to earlier initiation of reproductive phase. Whereas, moisture stress faced by

Table 1. Leaf area duration (days) at 0-30 DAS interval of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation

Treatments	2019-20					2020-21					Pooled				
	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)
N_1	4.8	5.0	5.0	4.8	**4.9**	4.3	4.4	4.3	4.3	**4.3**	4.5	4.7	4.7	4.5	**4.6**
N_2	6.4	6.5	6.5	6.5	**6.5**	5.6	5.9	5.9	5.7	**5.8**	6.0	6.2	6.2	6.1	**6.1**
N_3	7.6	7.8	8.0	8.0	**7.8**	6.6	7.0	7.1	7.2	**7.0**	7.1	7.4	7.5	7.6	**7.4**
N_4	8.3	8.5	8.7	8.8	**8.5**	7.4	7.6	7.8	8.0	**7.7**	7.8	8.0	8.2	8.4	**8.1**
Mean (I)	**6.7**	**6.9**	**7.0**	**7.0**		**5.9**	**6.2**	**6.3**	**6.3**		**6.3**	**6.6**	**6.7**	**6.6**	

	2019-20 SEm±	2019-20 CD (P = 0.05)	2020-21 SEm±	2020-21 CD (P = 0.05)	Pooled SEm±	Pooled CD (P = 0.05)
I	0.31	NS	0.32	NS	0.30	NS
N	0.30	0.9	0.31	0.9	0.30	0.9
N at I	0.60	NS	0.63	NS	0.59	NS
I at N	0.60	NS	0.63	NS	0.59	NS

Table 2. Leaf area duration (days) at 30-60 DAS interval of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation

Treatments	2019-20					2020-21					Pooled				
	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean(N)
N_1	22.0	24.9	24.4	23.3	**23.6**	19.4	21.9	21.4	20.5	**20.8**	20.7	23.4	22.9	21.9	**22.2**
N_2	27.9	31.8	35.1	33.9	**32.2**	24.7	28.5	31.7	29.6	**28.6**	26.3	30.2	33.4	31.7	**30.4**
N_3	27.9	37.1	41.2	43.0	**37.3**	24.6	33.6	37.5	38.9	**33.6**	26.2	35.4	39.3	40.9	**35.5**
N_4	27.4	40.2	45.7	47.9	**40.3**	24.3	36.3	41.8	44.6	**36.8**	25.8	38.2	43.7	46.2	**38.5**
Mean (I)	**26.3**	**33.5**	**36.6**	**37.0**		**23.3**	**30.1**	**33.1**	**33.4**		**24.8**	**31.8**	**34.8**	**35.2**	

	2019-20 SEm±	2019-20 CD (P = 0.05)	2020-21 SEm±	2020-21 CD (P = 0.05)	Pooled SEm±	Pooled CD (P = 0.05)
I	0.95	3.3	0.79	2.7	0.69	2.4
N	0.74	2.2	0.80	2.4	0.60	1.8
N at I	1.48	4.3	1.61	4.7	1.20	3.5
I at N	1.60	3.7	1.60	3.7	1.25	2.9

Table 3. Leaf area duration (days) at 60-90 DAS interval of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation

Treatments	2019-20					2020-21					Pooled				
	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)
N_1	43.8	50.5	48.9	46.5	**47.4**	39.0	45.1	43.4	41.1	**42.1**	41.4	47.8	46.2	43.8	**44.8**
N_2	54.1	63.1	69.6	66.4	**63.3**	48.7	57.6	64.8	60.7	**57.9**	51.4	60.4	67.2	63.5	**60.6**
N_3	51.6	72.8	80.7	85.0	**72.5**	46.0	68.3	76.3	79.4	**67.5**	48.8	70.6	78.5	82.2	**70.0**
N_4	48.1	77.7	90.0	95.2	**77.7**	43.0	72.8	84.9	90.8	**72.9**	45.5	75.2	87.4	93.0	**75.3**
Mean (I)	**49.4**	**66.0**	**72.3**	**73.3**		**44.2**	**60.9**	**67.3**	**68.0**		**46.8**	**63.5**	**69.8**	**70.6**	

	2019-20 SEm±	2019-20 CD (P = 0.05)	2020-21 SEm±	2020-21 CD (P = 0.05)	Pooled SEm±	Pooled CD (P = 0.05)
I	1.07	3.7	1.41	4.9	1.12	3.9
N	1.23	3.6	1.40	4.1	1.13	3.3
N at I	2.46	7.2	2.80	8.2	2.26	6.6
I at N	2.39	5.5	2.81	6.4	2.25	5.2

Table 4. Leaf area duration (days) at 90 DAS-harvest interval of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation

Treatments	2019-20					2020-21					Pooled				
	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)
N_1	38.9	46.8	44.8	41.5	**43.0**	35.2	42.8	40.4	37.2	**38.9**	37.0	44.8	42.6	39.4	**40.9**
N_2	49.6	60.2	66.1	62.8	**59.7**	45.7	55.8	62.5	58.8	**55.7**	47.6	58.0	64.3	60.8	**57.7**
N_3	47.2	70.6	78.1	82.4	**69.6**	42.7	66.9	75.1	78.5	**65.8**	44.9	68.8	76.6	80.4	**67.7**
N_4	43.2	75.3	87.6	93.2	**74.8**	39.0	71.4	83.7	89.2	**70.8**	41.1	73.3	85.7	91.2	**72.8**
Mean (I)	**44.7**	**63.2**	**69.2**	**70.0**		**40.6**	**59.2**	**65.4**	**65.9**		**42.7**	**61.2**	**67.3**	**67.9**	

	2019-20 SEm±	2019-20 CD (P=0.05)	2020-21 SEm±	2020-21 CD (P=0.05)	Pooled SEm±	Pooled CD (P=0.05)
I	1.16	4.0	0.63	2.2	0.54	1.9
N	1.31	3.8	1.28	3.7	1.17	3.4
N at I	2.62	7.7	2.55	7.5	2.34	6.8
I at N	2.55	5.8	2.30	5.3	2.10	4.8

Table 5. Number of days to 50% flowering of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation

Treatments	2019-20					2020-21					Pooled				
	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)	I_1	I_2	I_3	I_4	Mean (N)
N_1	98	98	98	98	**98**	107	107	107	107	**107**	103	102	102	103	**102**
N_2	97	97	96	96	**97**	106	105	105	105	**105**	102	101	101	101	**101**
N_3	98	96	95	94	**96**	106	105	104	103	**104**	102	100	99	99	**100**
N_4	98	96	94	94	**95**	107	104	103	103	**104**	102	100	98	98	**100**
Mean (I)	**98**	**97**	**96**	**96**		**107**	**105**	**105**	**104**		**102**	**101**	**100**	**100**	

	2019-20 SEm±	2019-20 CD (P=0.05)	2020-21 SEm±	2020-21 CD (P=0.05)	Pooled SEm±	Pooled CD (P=0.05)
I	0.6	NS	0.5	NS	0.3	1
N	0.5	1	0.5	2	0.4	1
N at I	1.0	NS	1.0	NS	0.7	NS
I at N	1.0	NS	1.0	NS	0.7	NS

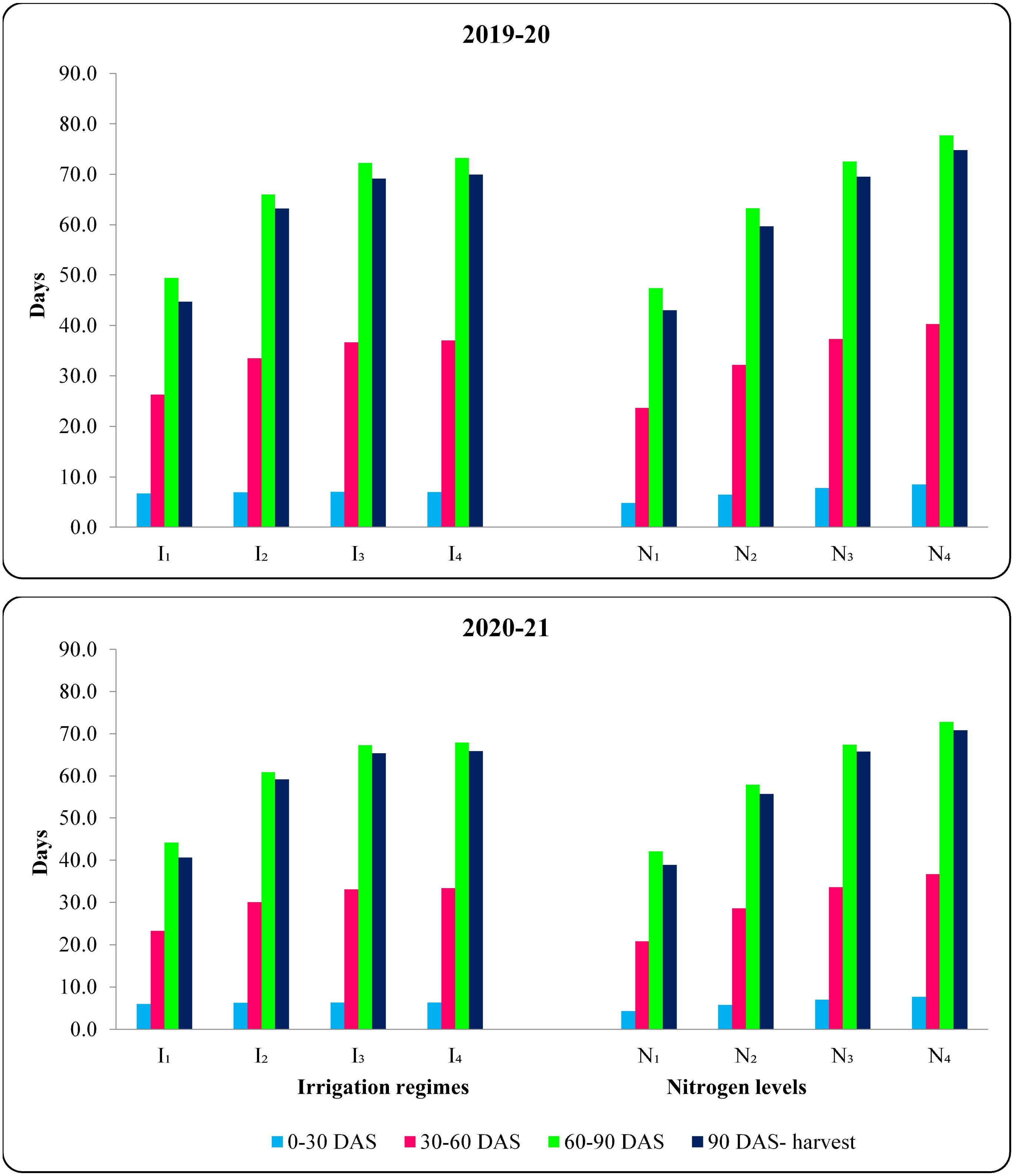

Figure 1. Leaf area duration (LAD) at different growth stages of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation.

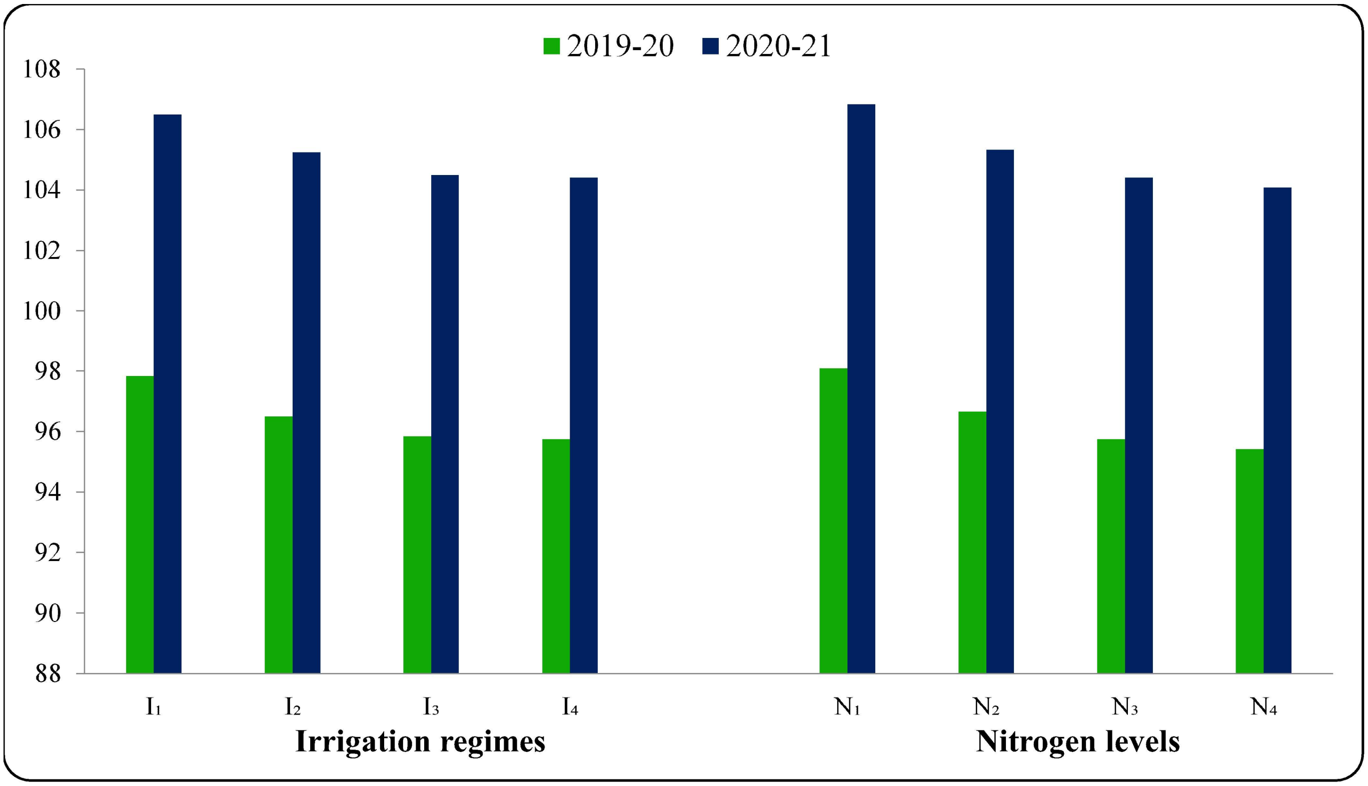

Figure 2. Leaf area duration (LAD) at different growth stages of aerobic rice as influenced by irrigation regimes and nitrogen levels under drip irrigation.

the crop at 1.25 Epan might have delayed flowering due to poor growth. These results are in accordance with the findings of Sudharani (2007), Rai and Kushwaha (2008), Basava (2012) and Prashant *et al*. (2019).

Among the different nitrogen levels tried, early flowering was observed with the supply of 180 kg N ha^{-1} followed by 150 kg N ha^{-1}, 120 kg N ha^{-1} and 90 kg N ha^{-1} with significant disparity in number of days to 50 % flowering between any two of the four levels during the first year of study.

Whereas during the second year of study, among the different nitrogen levels, 180 kg N ha^{-1}, 150 kg N ha^{-1} and 120 kg N ha^{-1} were comparable with respect to number of days to attain 50% flowering. However, 90 kg N ha^{-1} took more number of days to attain 50% flowering, which was significantly greater than the remaining nitrogen levels.

In the pooled mean, 180 kg N ha^{-1} and 150 kg N ha^{-1} recorded similar number of days to 50% flowering and both were significantly lower than 120 and 90 kg N ha^{-1} with respect to days to flowering.

The lower nitrogen dose of 90 kg N ha^{-1} resulted in delayed flowering during both the years of study and in the pooled mean. This might be due to the fact that inadequate nitrogen application subsequently decreased nitrogen absorption and reduced the plant vegetative growth leading to delayed flowering. These results are in accordance with the findings of Mahajan *et al*. (2012), Diproshan (2015) and Padmaja and Reddy (2018).

Interaction effect of irrigation regimes and nitrogen levels did not show significant influence on days to 50 % flowering.

Days to maturity

Irrigation regimes, nitrogen levels and their interaction failed to exert significant influence on number of days taken to attain maturity during both the years of investigation and in the pooled mean (Table 6).

However, nitrogen application of 90 kg N ha^{-1} took more number of days to attain maturity. Drip irrigation scheduled at 1.25 Epan, on the other hand, took more days to mature during both the years of study and in the pooled mean.

From the results of two years study, it can be concluded that at higher irrigation regimes and nitrogen levels, aerobic rice maintained green leaf area for a longer duration of time. Whereas, inadequate supply of nitrogen delayed flowering due to nutrient stress, while the effect of irrigation regimes on days to 50% flowering was observed only in the pooled mean, in which lower irrigation regimes resulted in delayed flowering. Irrigation regimes and nitrogen levels failed to exhibit any influence on number of days to maturity.

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AVAILABLE SOIL MICRONUTRIENT STATUS AS INFLUENCED BY TILLAGE PRACTICES, NUTRIENT LEVELS AND FOLIAR APPLICATION AFTER REDGRAM (*Cajanus cajan* L.)

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ABSTRACT

A field experiment was conducted during two consecutive *kharif* seasons of 2019-20 and 2020-21 to study the influence of tillage, nutrient levels and foliar sprays on post-harvest soil available micro nutrient status of redgram on sandy loam soil which was low in available nitrogen, medium in available phosphorus and available potassium. The experiment was conducted in a split - split plot design, consisting of three tillage practices as main plots, three nutrient levels in sub plots and three foliar sprays in sub- sub plots. Tillage, nutrient and foliar sprays could not exerted significant influence on post-harvest soil available micronutrient status. But higher soil available micronutrient content was recorded with vertical tillage with subsoiler upto 60 cm deep at 1 m interval with application of 125% RDF and foliar application of KNO_3 @ 1% twice with 15 days interval from 50 per cent flowering stage.

KEYWORDS: Foliar sprays, Micronutrients, Nutrient levels, Redgram and Tillage

INTRODUCTION

Pulses play an important role in Indian agriculture and source of protein for the poor as well as for the vegetarians which constitute major population of the country. Pulses mainly include chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea. The split grains of pulses called dal are excellent source of high quality protein, essential amino and fatty acids, fibers, minerals, vitamins and help to check obesity, diabetes besides fixing atmospheric nitrogen up to 200 kg ha^{-1} (Anonymous, 2010). Redgram (*Cajanus cajan* L.) is one of the important pulse crops of India and ranks second after chickpea in area and production. In India redgram was grown over an area of 4.45 million hectares with production of 3.83 million tonnes and 937 kg ha^{-1} productivity (Anonymous, 2020). In Andhra Pradesh, redgram is grown under rainfed conditions to an extent of 2.43 lakh hectares with an annual production of 1.19 lakh tonnes and productivity of 486 kg ha^{-1} (Anonymous, 2020).

Tillage, nutrient management is also described as the technique of using optimum effective dose of sufficient and balanced fertilizers in combination with foliar sprays to make nutrients more available and most effective for maintaining higher yields without exposing soil native nutrients and polluting the environment. Furthermore, many benefits can also be gained from using integrated tillage and nutrient management practices which also act a driving force to support the plans for improving post-harvest soil fertility. Vertical tillage with subsoiler, which loosens the subsoil without inverting and aimed at stimulating greater and faster penetration of roots and helps in increasing the availability of nutrients and moisture to the plants. (Reeves and Mullins, 1995; Tursic *et al*., 1998). Nutrient management practices may improve micronutrients *viz*., copper, manganese, iron and zinc availability in soil due to higher nutrient doses which enhances mineralization and availability of nutrients as well as they increase root nodules formation on roots and soil microbial activity. Usually, the farmer's fertilizer programs focus solely on soil applied NPK, without plans for foliar application. This is necessary to find the appropriate land configuration and techno-economic nutrient management package for redgram production under prevailing conditions. Hence, keeping all these points in view, the present investigation is planned entitled with effect of different tillage, nutrient management practices and foliar sprays on post-harvest soil available micro nutrient status after redgram.

MATERIAL AND METHODS

A field experiment was conducted by Department of Agronomy at S.V. Agricultural College, Tirupati,

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Acharya N.G. Ranga Agricultural University, Andhra Pradesh during two consecutive *kharif* seasons of 2019-20 and 2020-21 to study the post-harvest soil available micronutrient status as influenced by tillage practices, nutrient levels and foliar application of KNO_3 and borax after redgram. The soil of the experimental field was sandy clay loam in texture, low in available N, medium in available P, and available K (Table 1). Pigeonpea variety LRG-52 was used for experimentation. The experiment was laid out in split-split design with three tillage practices (T_1 : Conventional tillage with tractor drawn cultivator, T_2 : Ploughing with duck foot cultivator upto a depth of 30 cm and T_3 : Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval) in main plots, three nutrient levels *viz*., N_1 : 75% RDF, N_2 : 100% RDF (20 : 50 : 00 kg ha^{-1}) and N_3 : 125% RDF in subplots and three foliar sprays (F_1 : Control - No spray, F_2 : Borax - 0.1% F_3 : KNO_3 @ 1%) in sub-sub plots.

The initial representative soil samples were taken at a depth of 0-20, 20-40 and 40-60 cm from each plot following the existing procedure. The sample was air dried, powdered, sieved through 2 mm sieve and used for analysis of micronutrients *viz.,* zinc, copper, iron and manganese. After harvesting, soil samples were collected from the root zone depth at 0-20, 20-40, and 40-60 cm from each plot and composite samples were prepared for chemical analysis. Twenty grams of soil was shaken with 40 ml of DTPA extract of pH 7.3 for 2 hours, the contents were filtered and in the filtrate iron, manganese, zinc and copper were determined by using atomic absorption spectrophotometer (Varian A A 240 FS) (Lindsey and Norvell, 1978) and expressed in mg kg^{-1}.

Nutrient	Wave length (nm)	Lamp current (milli amperes)
Zinc	213.9	5
Copper	327.4	4
Iron	372.0	5
Manganese	403.1	5

RESULTS AND DISCUSSION

Post-harvest soil available micronutrients

During both the years of experimentation and in pooled mean, the post-harvest soil available micronutrient status of copper, manganese, iron and zinc at different depths was not significantly influenced by tillage, nutrient management practices and foliar sprays as well as their interaction during both the years of investigation inclusive of pooled mean.

Post-harvest soil available micronutrients at 0-20 cm depth

The soil available micronutrients *viz.*, copper, manganese, iron and zinc content were recorded higher

Table 1. Initial available micronutrient status after redgram

Particulars	Soil depth (cm)			Method adopted
	0-20	20-40	40-60	
Available N (kg ha^{-1})	152	108	90	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	32	27	21	Olsen's method (Olsen *et al*., 1954)
Available K_2O (kg ha^{-1})	218	180	162	Flame photometry (Jackson, 1973)
DTPA extractable micronutrients (mg kg^{-1})				
Copper	0.80	0.65	0.56	
Manganese	3.50	2.98	2.45	DTPA extraction (Lindsey and Norvell, 1978)
Iron	3.01	2.65	2.24	
Zinc	1.11	0.91	0.86	

Table 2. Post-harvest soil available micronutrient content (mg kg^{-1}) at 0-20 cm depth as influenced by tillage, nutrient levelsand foliar application afterredgram

Treatments	Copper		Pooled	Manganese		Pooled	Iron		Pooled	Zinc		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)												
T_1 : Conventional tillage with tractor drawn cultivator	0.77	0.75	0.76	3.27	2.91	3.09	2.70	2.59	2.65	0.89	0.81	0.85
T_2 : Ploughing with duck foot cultivator upto a depth of 30 cm	0.81	0.78	0.80	3.36	2.99	3.18	2.78	2.66	2.72	0.92	0.84	0.88
T_3 : Vertical Tillage with subsoilerupto 60 cm deep at 1.0 m interval	0.83	0.80	0.82	3.45	3.07	3.26	2.85	2.74	2.79	0.95	0.86	0.90
SEm ±	0.020	0.020	0.020	0.084	0.070	0.08	0.068	0.065	0.066	0.053	0.048	0.050
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plots : Nutrient management practices (N)												
N_1 : 75 % RDF	0.79	0.76	0.77	3.24	2.88	3.06	2.68	2.57	2.62	0.89	0.81	0.85
N_2 : 100 % RDF	0.80	0.78	0.79	3.36	2.99	3.18	2.80	2.69	2.74	0.92	0.84	0.88
N_3 : 125 % RDF	0.83	0.80	0.82	3.48	3.10	3.29	2.85	2.74	2.79	0.95	0.86	0.90
SEm ±	0.016	0.016	0.016	0.069	0.061	0.070	0.063	0.060	0.061	0.028	0.025	0.026
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub sub plots : Foliar sprays (F)												
F_1 : Control (No spray)	0.80	0.78	0.79	3.30	2.94	3.12	2.75	2.64	2.70	0.85	0.77	0.81
F_2 : Borax 0.1%	0.81	0.79	0.80	3.36	2.99	3.18	2.80	2.69	2.74	0.92	0.84	0.88
F_3 : KNO_3 1%	0.80	0.77	0.79	3.39	3.02	3.20	2.80	2.69	2.74	0.98	0.89	0.93
SEm ±	0.016	0.016	0.016	0.054	0.048	0.051	0.063	0.060	0.061	0.041	0.037	0.039
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction												
T × N												
SEm ±	0.028	0.027	0.027	0.1230	0.1095	0.1162	0.108	0.103	0.105	0.048	0.044	0.046
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F												
SEm ±	0.029	0.026	0.027	0.093	0.083	0.088	0.108	0.103	0.105	0.070	0.064	0.067
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F												
SEm ±	0.029	0.026	0.027	0.093	0.083	0.088	0.108	0.103	0.105	0.070	0.064	0.067
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F												
SEm ±	0.049	0.047	0.048	0.162	0.144	0.153	0.188	0.180	0.184	0.122	0.111	0.117
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Post-harvest soil available micronutrient content (mg kg^{-1}) at 20-40 cm depth as influenced by tillage ,nutrient levels and foliar application after redgram

Treatments	Copper		Pooled	Manganese		Pooled	Iron		Pooled	Zinc		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)												
T_1 : Conventional tillage with tractor drawn cultivator	0.59	0.50	0.54	2.80	2.35	2.58	2.27	2.06	2.16	0.85	0.69	0.77
T_2 : Ploughing with duck foot cultivator upto a depth of 30 cm	0.61	0.52	0.57	2.88	2.42	2.65	2.33	2.12	2.23	0.88	0.72	0.80
T_3 : Vertical Tillage with subsoilerupto 60 cm deep at 1.0 m interval	0.63	0.54	0.58	2.95	2.48	2.71	2.40	2.18	2.29	0.90	0.74	0.82
SEm ±	0.009	0.01	0.01	0.073	0.061	0.067	0.057	0.052	0.055	0.051	0.041	0.046
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plots : Nutrient management practices (N)												
N_1 : 75 % RDF	0.59	0.51	0.55	2.78	2.33	2.55	2.24	2.04	2.14	0.85	0.69	0.77
N_2 : 100 % RDF	0.61	0.52	0.56	2.88	2.42	2.65	2.35	2.14	2.25	0.87	0.71	0.79
N_3 : 125 % RDF	0.63	0.54	0.58	2.98	2.50	2.74	2.40	2.18	2.29	0.90	0.74	0.82
SEm ±	0.008	0.007	0.007	0.060	0.050	0.055	0.051	0.046	0.048	0.026	0.022	0.024
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub sub plots : Foliar sprays (F)												
F_1 : Control (No spray)	0.61	0.52	0.56	2.83	2.37	2.60	2.31	2.10	2.21	0.80	0.66	0.73
F_2 : Borax 0.1%	0.61	0.52	0.57	2.88	2.42	2.65	2.33	2.12	2.23	0.88	0.72	0.80
F_3 : KNO_3 1%	0.60	0.52	0.56	2.93	2.46	2.69	2.33	2.12	2.23	0.94	0.77	0.85
SEm ±	0.013	0.01	0.01	0.045	0.038	0.041	0.053	0.048	0.050	0.039	0.032	0.035
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction												
T × N												
SEm ±	0.014	0.012	0.013	0.105	0.088	0.097	0.090	0.082	0.086	0.046	0.038	0.042
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F												
SEm ±	0.022	0.018	0.020	0.080	0.067	0.074	0.090	0.082	0.086	0.067	0.055	0.061
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F												
SEm ±	0.022	0.018	0.020	0.080	0.067	0.074	0.090	0.082	0.086	0.067	0.055	0.061
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F												
SEm ±	0.038	0.032	0.035	0.138	0.116	0.127	0.156	0.142	0.149	0.116	0.095	0.105
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Post-harvest soil available micronutrient content (mg kg^{-1}) at 40-60 cm depth as influenced by tillage ,nutrient levels and foliar application after redgram

Treatments	Copper		Pooled	Manganese		Pooled	Iron		Pooled	Zinc		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)												
T_1 : Conventional tillage with tractor drawn cultivator	0.44	0.44	0.44	2.36	2.12	2.24	1.92	1.73	1.82	0.71	0.64	0.67
T_2 : Ploughing with duck foot cultivator upto a depth of 30 cm	0.45	0.45	0.45	2.42	2.18	2.30	1.98	1.78	1.88	0.74	0.67	0.70
T_3 : Vertical Tillage with subsoilerupto 60 cm deep at 1.0 m interval	0.46	0.46	0.46	2.50	2.25	2.38	2.04	1.84	1.94	0.75	0.68	0.71
SEm ±	0.006	0.006	0.006	0.062	0.056	0.059	0.048	0.043	0.046	0.042	0.038	0.040
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plots : Nutrient management practices (N)												
N_1 : 75 % RDF	0.44	0.44	0.44	2.34	2.11	2.22	1.92	1.73	1.82	0.71	0.64	0.67
N_2 : 100 % RDF	0.45	0.45	0.45	2.42	2.18	2.30	2.00	1.80	1.90	0.73	0.66	0.69
N_3 : 125 % RDF	0.46	0.46	0.46	2.50	2.25	2.38	2.04	1.84	1.94	0.75	0.68	0.71
SEm ±	0.006	0.006	0.006	0.050	0.045	0.048	0.044	0.040	0.042	0.022	0.020	0.021
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub sub plots : Foliar sprays (F)												
F_1 : Control (No spray)	0.45	0.45	0.45	2.38	2.14	2.26	1.98	1.78	1.88	0.68	0.612	0.646
F_2 : Borax 0.1%	0.45	0.45	0.45	2.42	2.18	2.30	2.00	1.80	1.90	0.73	0.657	0.6935
F_3 : KNO_3 1%	0.45	0.45	0.45	2.46	2.21	2.34	2.00	1.80	1.90	0.78	0.702	0.741
SEm ±	0.009	0.009	0.009	0.038	0.0342	0.0361	0.044	0.040	0.042	0.032	0.029	0.030
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction												
T × N												
SEm ±	0.010	0.010	0.010	0.088	0.0792	0.0836	0.066	0.059	0.063	0.038	0.034	0.036
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F												
SEm ±	0.016	0.016	0.016	0.068	0.061	0.065	0.078	0.070	0.074	0.056	0.050	0.053
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F												
SEm ±	0.016	0.016	0.016	0.068	0.061	0.065	0.078	0.070	0.074	0.056	0.0504	0.0532
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F												
SEm ±	0.028	0.028	0.028	0.116	0.104	0.110	0.134	0.121	0.127	0.097	0.087	0.092
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

with vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) with no significant disparity among tillage treatments during both the years of experimentation as well as in pooled mean. The soil available micronutrients were maximum with application of 125% RDF (N_3), followed by 100% RDF (N_2) and 75% RDF (N_1) with no significant disparity among the treatments during both the instances of study and in pooled mean. Foliar sprays failed to exert significant influence on soil available micronutrients during the two years of investigation (Table 2).

The interaction of tillage, nutrient management practices and foliar sprays was found to be non-significant in affecting post-harvest nutrient availability of copper, manganese, iron and zinc during both the years of study.

Post-harvest soil available micronutrients at 20-40 cm depth

Tillage, nutrient management practices and foliar sprays as well as their interaction could not exert significant influence on post-harvest soil available micronutrient status during both the years of study inclusive of pooled mean (Table 3).

Available micronutrients *viz.,* copper, manganese, iron and zinc content were maximum with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) with no significant disparity among the treatments during both the years of study and in pooled mean. Among the nutrient levels, higher micronutrient contents *viz.,* of copper, manganese, iron and zinc were observed with 125% RDF (N_3) followed by 100% RDF (N_2) and 75% RDF (N_1) and found at par during the two years of investigation. The effect of foliar treatments on available micronutrient status was found to be non-significant during both the years of study and in pooled mean.

Post-harvest soil available micronutrients at 40-60 cm depth

Post-harvest soil available micronutrients did not differed with tillage, nutrient management practices and foliar sprays as well as their interaction during both the years of investigation and in pooled mean. Higher values of soil available micronutrient *viz.,* copper, manganese, iron and zinc content were recorded with vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) with no significant disparity between any two tillage treatments during both the years of experiment.

The available micronutrient status was maximum with application of 125% RDF (N_3), followed by 100% RDF (N_2) and 75% RDF (N_1) with no significant disparity among the treatments during both the years of study. Among the tillage practices studied, maximum availability of micronutrients in soil after harvest of redgram was recorded (Table 4) with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) during both the years of experiment. This might be due to higher root activity and favourable soil moisture conditions that increased the mineralisation of nutrients and helped to increase the availability of nutrients. Application of 125% RDF (N_3) recorded higher micronutrient availability at different depths might be due to more amount of nitrogen, phosphorus and potassium applied to soil which enhances micronutrient content in soil after harvesting of redgram. Foliar sprays failed to exert significant influence on available micronutrient content during the two years of investigation. But higher soil available micronutrients content was registered with foliar application of KNO_3 1% (F_3) might be attributed to the increased nodule count which was responsible for increased nitrogen fixation as well as micronutrient mineralization and transformed to available form (Nanasaheb, 2012).

It was evident that postharvest soil available micronutrient status was not significantly influenced by different tillage, nutrient levels and foliar sprays after redgram in sandy clay loam soils of Tirupati.

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SELECTION OF BEST CROP UNDER UNCERTAINTY IN AGRICULTURE

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ABSTRACT

Decision making process involves selecting the best among several decisions through a proper evaluation of the parameters of each decision environment. An attempt is made under uncertainty conditions by nature of the farmer. This study is not only introduces concepts, principles and approaches for addressing uncertainty in decision making but also gives overview regarding practical method for modelling decisions under uncertainty and selecting decision alternatives that optimise the decision maker's objectives. A farmer who followed multiple cropping system containing crops Groundnut, Paddy, Sunflower, Red gram, Cotton and Sesame. For that I have taken two factors *i.e.* production and price. From that I have drawn four variables i.e. good yield; high price, good yield; low price, poor yield; good price and poor yield; low price. Different methods were fitted to the data. If the farmer is optimistic, redgram is the best alternative under MAXIMAX criterion. If the farmer is pessimistic, Paddy is the best alternative as per MAXIMIN criterion. If the farmer is mixture of optimism and pessimism, redgram is best alternative as per HURWICZ criterion. If farmer considers always opportunity cost, sesame is best alternative as per SAVAGE MINIMAX REGRET criterion. If farmer considers the instances of each and every situation any event may occur in equal chance, Groundnut is the best alternative as per LAPLACE criterion. Based on this study farmer can rely for which crop to be taken for the next year based on the current production, prices and his behaviour irrespective of other factors.

KEYWORDS: HURWICZ, LAPLACE, MAXIMAX, MAXIMIN, Uncertainty

INTRODUCTION

The risk and uncertainty behaviour of decision makers have been well equipped with respect to individual agricultural producers. The terms 'risk' and 'uncertainty' can be defined in different ways. The major common difference is to suggest that risk is imperfect knowledge where the probabilities of the possible outcomes are known whereas uncertainty exists when these probabilities are not known.

A study on optimum allocation of agricultural land to the vegetable crops under uncertain profits usingfuzzy multi-objective linear programming-revealed the at optimum cropping pattern susing Linear Programming (LP) technique in case of fixed prices (profits) of crops. But instability in prices is high for vegetable crops due to their costly cultivation with high risk of profitability even though enhanced profits over food crops. This study makes an effort to compute the volatility in profits of vegetable crop sussing max-min approach of fuzzy programming. Results showed that the proper land utilization and proper cropping pattern is needed at farmers level itself. The farmer must grow the vegetable cropsin a way that it should be picked and be marketed in whole period to find at least best weighted return as an assured profit of 10.89 lakhs in spite of fluctuating prices (Kumari *et al.,* 2014).

Ahuja (2010) defined risk as a situation in which the outcome of a decision is uncertain, but the probability of each possible outcome is known and can be estimated.In farming, many farm management decisions can be taken with no need to take explicit account of the risks involved. But some risky farm decisions will warrant giving more attention to the choice among the available alternatives.

Mostly in the agriculture sector, profit or loss are influenced by demand, supply, price of a crop, cost of cultivation etc. Sothe maximization of profit became a multi objective decision-making problem with unstable choices. Agricultural production is biological in nature and highly depends on agro-climatic conditions and is being carried out in small or medium sized farms. Therefore, the farmer must make decisions in extremely unstable and insecure circumstances (Nieuwoudt, 1972). Hence this study is taken up to give some hope and scope for the farming community. With decisions under uncertainty occur agroclimatic conditions (favourable/ moderately favourable/unfavourable), market price (good/

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average/poor), production (high/average/low) and pest instances (high/average/low)etc.

Sahin *et al.* (2008) determine the cattle fattening breed, which maximizes the net profit for the producers under risk and uncertainties. The Wald's, Hurwicz's, Maximax, Savage's, Laplace's and Utility criterions were used. On the other hand, the decision on which crops to include in crop rotation is one of the most important decisions in field crop farm management. Agronomic, economic and market information about each individual crop constitutes an informative basis for decision-making. There is a significant amount of valuable agronomic and market information already available on main crop production, including oil crops (Rozman *et al.,* 2006). However, the potential for a wider range of alternative crops, including oil pumpkin (Bavec and Bavec, 2006), should be evaluated in order to determine their breakcrop characteristics and the benefits and challenges which they bring to systems (Robson *et al.,* 2002).

Raju *et al.* (2000) studied on optimum cropping pattern for Sriramsagar project with an objective of maximization of net benefits. Uncertainty in the inflows arising out in the uncertainty in the rainfall is tackled through chance stochastic programming. Inflows at 4 levels of dependability *viz.,* 75.00, 80.00, 85.00 and 90.00 per cent were considered in this study to obtain various possible optimal cropping patterns and optimal operating policies. Results indicated that for 90.00 per cent dependability level, paddy 450 (summer) and paddy (winter) occupied 62,930 ha and 14,700 ha area, respectively.

Frank and Ragnar (1999), emphasized that firm behaviour under risk with the help of panel data set of Norwegian salmon farms, showed that the structure of production risk plays an important role in production decisions of risk-averse producers, both with respect to optimal input levels and to adoption of new technologies. Farms are heterogeneous with respect to production risk. In other words, farms employing the same input levels have different levels of output risk. Inputs are found to be risk-controlling instruments. Since production risk is an inherent feature of the production process in most primary industries

Bowden *et al.* (1985) explained the research paradigm for system agriculture. According to them, agriculture was a complicated human activity involving gun certainty and change. There was a need for system thinking considering agriculture with a sense of its complex wholesomeness and to take active and feasible action. According to them, Farming System Research was primarily concerned with the adoption of existing agricultural research to provide technology, relevant to farm resources.

MATERIAL AND METHODS

Let D_i be the set of crops or decision alternatives or strategies (for i = 1, 2,3., m). E be the set of situations or events E_j (for j = 1, 2, 3., n) R_{ij} be the set of payoffs (net returns) obtained by choosing crop D_i if state E_j occurs.

1. Maximax Criterion

It is also known as the criterion of optimism, is used when the decision-maker is optimistic about future. Maximum payoffs is identified and the corresponding alternative is selected.

Maximax criterion (optimism)

$$\text{Maximax criterion} = \text{Max}\ (\max R_{ij})$$

2. Maximin Criterion

It is also known as the criterion of pessimism, is used when the decision-maker is pessimistic about future. Maximin criterion implies the maximisation of the minimum payoff. The pessimistic decision-maker locates the minimum payoff for each possible alternative. The maximum of these minimum payoffs is identified and the corresponding alternative is selected.

Maximin criterion/Wald's criterion(pessimism)

$$\text{Maximin criterion} = \text{Max}\ (\min R_{ij})$$

3. Hurwicz Criterion

The approach would be to take into account the degree or *index of optimism* or *pessimism* of the decision-maker in the process of decision-making. If degree of optimism is α, a constant lying between 0 and 1and the degree of pessimism will be 1-α. Then a weighted average of the maximum and minimum payoffs of an action with α and 1-α as respective weights is computed. The action with the highest average is regarded as optimal.

We know α nearer to unity indicates that the decision-maker is optimistic while a value nearer to zero evidents the decision maker is pessimistic.

Hurwicz's criterion

(H_i) =(maximum pay off)+ 1-α (minimum pay off)

$H_i = \alpha$ (row maximum) + $(1 - \alpha)$ (row minimum) – for positive payoffs (profits, revenues)

$H_i = \alpha$ (row minimum) + $(1 - \alpha)$ (row maximum) – for negative payoffs (costs, losses)

Best strategy will be Max { H_i } for positive payoffs, and Min { H_i } for negative payoffs.

4. Regret Criterion

Regret is the difference, which measures the magnitude of the loss incurred by not selecting the best alternative, is also known as opportunity loss or the opportunity cost.

Minimax regret criterion (savage's criterion)

Regrets = Maximum payoff- payoff

Minmax regrets = Min (maximum regrets)

5. Laplace Criterion

In the absence of any knowledge about the probabilities of occurrence of various states of nature, one possible way out is to assume that all of them are equally likely to occur. Using these probabilities, we compute the expected payoff for each course of action and the action with maximum expected value is regarded as optimal.

Laplace criterion / equal probability/ Rationality/ Bayes criterion

Expected Strategies $E(D_i)$ =

$\Sigma P_i R_{ij}$ (profit incurred under j^{th} market situation at i^{th} level of yield

Max $(E(D_i))$ = Max (average payoffs)

Select the action alternative with the best E (Si) as the optimal decision. "Best" means max for positive payoffs (profits, revenues) and min for negative payoffs (costs).

RESULTS AND DISCUSSION

A farmer from Kadapa district who followed multiple cropping systems is selected at random and collected data from him. Data contains the cost of cultivation, yields and market prices pertaining to six crops; groundnut, paddy, sunflower, red gram, cotton and sesame cultivated by him. profits for each crop under four different situations *viz.,* good yield with high market price; good yield with low market price; poor yield with high market price; and poor yield with low market price are calculated. He faced many challenges with fluctuated prices and uncertain yields due to many uncontrollable factors.

S. No	Crop	Cost of cultivation (₹ acre)	Yield (kg ac^{-1})		Price (₹ kg^{-1})	
			Good yield	Poor yield	High market price	Low market price
1	Groundnut	25,000	1600	350	60	35
2	Paddy	20,000	3600	1800	18	8
3	Sunflower	16,000	1200	400	55	20
4	Redgram	12,000	700	175	120	25
5	cotton	22,000	1000	300	55	25
6	Sesame	10,000	400	120	100	28

Cost of Cultivation Matrix

Profit matrix

		Profit in ('000) / acre at four different scenarios			
S. No.	**Crop**	**Good yield and High price**	**Good yield and Low price**	**Poor yield and high price**	**Poor yield and Low price**
1.	Groundnut	71	31	-4	-12.8
2.	Paddy	44.8	8.8	12.4	-5.6
3.	Sunflower	50	8	6	-8
4.	Redgram	72	5.5	9	-7.6
5.	cotton	33	3	-5.5	-14.5
6.	Sesame	30	1.2	2	-6.6

		Profit in ('000) / acre at four different scenarios				
S. No.	**Crop**	**Good yield and High price**	**Good yield and Low price**	**Poor yield and high price**	**Poor yield and Low price**	**Maximum pay off**
1.	Groundnut	71	31	-4	-12.8	71
2.	Paddy	44.8	8.8	12.4	-5.6	44.8
3.	Sunflower	50	8	6	-8	50
4.	Redgram	72	5.5	9	-7.6	72
5.	cotton	33	3	-5.5	-14.5	33
6.	Sesame	30	1.2	2	-6.6	30

Maximax criterion = Max (Maximum payoff)

= Max (71.0, 44.8, 50.0, 72.0, 33.0, 30.0)

= **72.0 (Redgram)**

Maximin criterion

		Profit in ('000) / acre at four different scenarios				
S. No.	**Crop**	**Good yield and High price**	**Good yield and Low price**	**Poor yield and High price**	**Poor yield and Low price**	**Minimum Pay off**
1.	Groundnut	71	31	-4	-12.8	-12.8
2.	Paddy	44.8	8.8	12.4	-5.6	-5.6
3.	Sunflower	50	8	6	-8	-8
4.	Redgram	72	5.5	9	-7.6	-7.6
5.	cotton	33	3	-5.5	-14.5	-14.5
6.	Sesame	30	1.2	2	-6.6	-6.6

Maximin criterion = Max (Minimum payoff)

= Max (-12.8, -5.6, -8.0,-7.6, -14.5, -6.6)

= **-5.6 (paddy)**

Hurwicz's criterion

		Profit in ('000) / acre at four different scenarios						
S. No.	**Crop**	**Good yield and High price**	**Good yield and Low price**	**Poor yield and high price**	**Poor yield and Low price**	**Maximum Pay off**	**Minimum Pay off**	**EMV (H_i) = α (maximum pay off) + 1-α (minimum pay off)**
1	Groundnut	71	31	-4	-12.8	71	-12.8	37.48
2	Paddy	44.8	8.8	12.4	-5.6	44.8	-5.6	24.64
3	Sunflower	50	8	6	-8	50	-8	26.8
4	Redgram	72	5.5	9	-7.6	72	-7.6	40.16
5	cotton	33	3	-5.5	-14.5	33	-14.5	14
6	Sesame	30	1.2	2	-6.6	30	-6.6	15.36

Generally α value lies between 0 to 1 with the intention of maximising the profit I have taken $\alpha = 0.6$ E.M.V **(H_i)** $=\alpha$ (maximum pay off) + 1-α (minimum pay off)

Minimax regret criterion

Redgram = 40.16

Regrets = maximum payoff - payoff

Minmax regrets = min(maximum regrets)

= min (83.8, 50.4, 58, 79.6, 47.5, 36.6)

= **36.6 (sesame)**

Laplace criterion

		Regret table			
Crop	**Good yield and High price**	**Good yield and Low price**	**Poor yield and high price**	**Poor yield and Low price**	**Maximum regrets**
Groundnut	71.0-71.0 = 0	71.0-31.0 = 40.0	71.0-(-4.0) = 75	71.0 -(-.8) = 83.8	83.8
Paddy	44.8-44.8 = 0	44.8-8.8 = 36.0	44.8-8.4 = 32.4	44.8-(-.6) = 50.4	50.4
Sunflower	50.0-50.0 = 0	50.0-8.0 = 42.0	50.0-6.0 = 44.0	50.0-(-8.0) = 58.0	58.0
Redgram	72.0-72.0 = 0	72.0-5.5 = 66.5	72.0-9.0 = 63.0	72.0-(-.6) = 79.6	79.6
Cotton	33.0-33.0 = 0	33.0-3.0 = 30.0	33.0-(-.5) = 38.5	33.0-(-4.5) = 47.5	47.5
Sesame	30.0-30.0 = 0	30.0-1.2 = 28.8	30.0-2.0 = 28.0	30.0-(-.6) = 36.6	36.6

		Profit in ('000) / acre at four different situations			
Crop	**Good yield and High price (E_i) = 0.25**	**Good yield and Low price (E_2) = 0.25**	**Poor yield and High price (E_3) = 0.25**	**Poor yield and Low price (E_4) = 0.25**	**Expected and Strategies E(S_i)**
Groundnut	71	31	-4	-12.8	21.4
Paddy	44.8	8.8	12.4	-5.6	15.1
Sunflower	50	8	6	-8	14
Redgram	72	5.5	9	-7.6	19.7
Cotton	33	3	-5.5	-14.5	4
Sesame	30	1.2	2	-6.6	6.7

Expected Strategies $E(S_i) = \Sigma P_i R_{ij}$ (profit incurred under j^{th} market situation at i^{th} level of yield)

$$Max (E(S_i)) = Max (21.4, 15.1, 14.0, 19.7, 4.0, 6.7)$$

$$= \mathbf{21.4\ (Groundnut)}$$

From the study I have drawn these conclusions which optimise the farmer's profit in view of his nature from different methodologies taken.

- If the farmer is optimistic, **Redgram** is a better option
- The suitable crop for the pessimistic farmer is **Paddy**.
- **Redgram** is the better choice for the farmer who is neither optimistic nor pessimistic with (0.6 weightage for optimism and 0.4 weightage for pessimism) the intention of maximum profit.
- **Sesame** is the best alternative if he accounts for opportunity loss as a risk avert from his previous experience.
- If there is equal chance for happening of any one of the four alternatives in the coming season the best choice for him (risk bearer) is **Groundnut** to achieve optimum profits even the production and market price is not known.

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CONSTRAINTS FACED BY FARM WOMEN IN HOME AND AGRICULTURAL ACTIVITIES AND SUGGESTIONS TO OVERCOME THEM IN TELANGANA STATE

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ABSTRACT

Agriculture is impracticable without the involvement of women. Farm women dominate the work force in agriculture and participate in most of the farm operations. In addition to farm activities, women also involve in copious works at home. Farm women face many constraints in due process of bearing the dual responsibilities at farm and home. In this study, various socio-personal, economic and technological constraints perceived by farm women in Telangana state were analysed and were ranked based on the descending order of the frequencies obtained for each constraint. Study revealed that 23 constraints out of the 34 constraints were ranked as major constraints by more than fifty per cent of farm women respondents in the study area. Seven suggestions were expressed by majority of farm women out of the 10 suggestions given by them to overcome their constraints.

KEYWORDS: Agriculture, Economic constraints, Farm women, Socio-personal constraints, Technological constraints

INTRODUCTION

Farm women are the major contributors to agriculture and allied sectors. They are indispensable to agriculture likewise agriculture is to nation. Farm women contribute equally, also in some cases more than men to farming in addition to obligations they bear at home, such as domestic work and child rearing. Despite their varied tasks at home and on the farm, women face numerous challenges that affect their position and recognition in the house and society. Farm women's productivity is influenced by the constraints they confront on the farm. Providing a mechanism to minimise or reduce the limits which farm women experience will ensure higher prosperity to nation. Hence, this study was taken up to analyse the constraints faced by the farm women in different spheres of their life.

MATERIAL AND METHODS

An *ex-post facto* research design was employed in the current investigation. Telangana state was purposively selected. One district each from three agro climatic zones of the state viz., Nizamabad from North Telangana zone, Sangareddy from Central Telangana zone and Nalgonda from South Telangana zone were purposively selected on the basis of highest number of farm women from each agro climatic zone. Four mandals from each district and two villages from each mandal were selected by using simple random sampling procedure and a total of 12 mandals and 24 villages were selected respectively. From each village, ten farm women were selected thus making a total of 240 respondents as the sample of the study. In this study, 'constraint' was operationalized as the obstacle perceived by the farm women in various spheres of their lives. A total of 34 constraints were identified and grouped into three categories as 'socio-personal', 'economic' and 'technological/on farm' constraints. Alongside constraints, 'suggestions' expressed by the farm women were documented and in this study 'suggestion' was operationalized as, 'the requirements expressed by the farm women in order to fulfil their needs'. The suggestions expressed by the farm women were keenly observed and framed into 10 major suggestions. The field investigation was carried out during the year 2017. The data was collected by administering the structured interview schedule to the farm women and were measured using frequency and percentage. The results were presented in table 1 and table 2 and necessary inferences were drawn.

RESULTS AND DISCUSSION

Constraints faced by farm women were classified into three major categories viz., socio-personal, economic and technological/on farm constraints and were presented in Table 1. Major socio-personal constraints faced by farm women were, 'being woman, it is difficult to perform certain farm operations' (89.17%), 'lack of control over

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use of income' (81.67%), 'male dominated society' (71.67%), 'lack of ownership of assets (land and farm machinery/tools)' (67.50%), 'illiteracy' (64.58%), 'dependency on others' (63.33%) and 'secondary status in decision making' (57.92%). Most of the farm women perceived 'health problems' (45.83%), 'lack of decision making power' (42.08%), 'lack of adequate time to work on farm due to domestic work' (40.00%), 'low self-confidence' (37.50%) and 'family and social conflict' (35.00%) as other socio-personal constraints in their lives.

The economic constraints faced by farm women were, 'discouraging agricultural price policy' (72.92%), 'poor economic condition' (63.75%), 'discrimination in payment of wages' (63.75%), 'lack of credit' (57.08%), 'costly agricultural inputs' (49.58%), 'difficulty in getting loans' (35.83%) and 'unavailability of subsidy on inputs' (34.58%).

With regard to major technological/on farm constraints faced by the farm women were 'non access to gender friendly technologies'(74.58%), 'lack of technical knowledge about improved farming activities' (73.75%), 'unavailability of inputs at right time and right quantities' (70.00%), 'unavailability of farm machinery at right time' (69.58%), 'lack of Information and Communication Technologies' (ICT's) (68.33%), 'lack of awareness about gender friendly technologies' (66.25%), 'lack of training programmes'(60.00%), 'poor or non-access to information sources' (60.00%), 'lack of irrigation' (56.25%), 'scarcity of labour' (55.42%), and 'small size of land holding' (50.83%). 'Inadequate extension services (48.75%), 'lack of direct extension contact' (39.17%), 'diminishing support from government for farm women' (35.83%) and 'qualitative degradation of inputs' (22.08%) were other technological/on farm constraints faced by the farm women.

Similar findings were reported by Tiwari (2010), Warkade (2010), Girade and Shambharkar (2012), Chayal *et al.* (2013), Thakur (2013), Rani (2014), Pooja *et al.* (2016), Chauhan (2018) and Shankarrao (2018).

'Being woman, it is difficult to perform certain farm operations' with first rank was perceived by 89.17 per cent of farm women as a major socio-personal constraint. Farm women with less physical strength compared to men farmers often depended on men or agricultural labourers for more physically demanding tasks in farming. They also perceived that their lack of enough strength in handling different agricultural tools and implements was restricting their efficiency in farming. 'Lack of control over use of income' (rank II) was deemed to be major constraint by most of the farm women (81.67%). Women in many households were not entitled to use and spend their self-earned income as well as family revenue for various family requirements due to the existing patriarchal society. Because of their lower educational background, men did not perceive women as capable of handling family financial concerns. As a result, many women felt deprived of their financial liberty at home and at work.

'Male dominated society' was witnessed by 71.67 per cent of farm women and it was ranked third in the socio-personal constraints. Since generations, a patriarchal structure had prevailed in society and women were considered as second to males in their homes, denied equal access to education as their male siblings, lacked asset ownership, financial autonomy and faced restrictions that hampered their social mobility. 'Lack of ownership of assets (land and farm machinery/tools)' (rank IV) was perceived as a constraint by 67.50 per cent of farm women. Many women do not have the ownership of land or machinery even though they are equal contributors on their farm. Women were not granted property alongside the male siblings in a household because as when they marry eventually, they become members of another household. In marital households, males hold the legal ownership of assets as the heads of the family due to existing patriarchal society. In some instances, women were given ownership of assets but in reality, that was not much beneficial to them and they did not have the autonomy of sale or further development of those assets.

'Illiteracy' with fifth rank was perceived as a constraint by 64.58 per cent of farm women. Farm women had less access to education because farming dependent households live in rural areas with few or no educational facilities or due to poor economic condition or due to the belief held by their parents that women do not need education. In certain circumstances, women have been denied access to higher education because their parents were unwilling to send their daughters away from home for study due to a traditional mindset. Illiteracy harmed women by limiting their knowledge, hindering them from making rational decisions and making them feel inferior to males. It also prevented them from actively participating in financial transactions and having social mobility.

Constraints faced by the farm women in different spheres of their life

Table 1. Constraints faced by farm women

S. No.	Constraints	F	%	Rank
I.	**Socio-personal constraints**			
1.	Being woman, it is difficult to perform certain farm operations	214	89.17	I
2.	Lack of control over use of income	196	81.67	II
3.	Male dominated society	172	71.67	III
4.	Lack of ownership of assets (Land and farm machinery/tools)	162	67.50	IV
5.	Illiteracy	155	64.58	V
6.	Dependency on others	152	63.33	VI
7.	Secondary status in decision making	139	57.92	VII
8.	Health problems	110	45.83	VIII
9.	Lack of decision-making power	101	42.08	IX
10.	Lack of adequate time to work on farm due to domestic work	96	40.00	X
11.	Low self confidence	90	37.50	XI
12.	Family and social conflict	84	35.00	XII
II.	**Economic constraints**			
1.	Discouraging agricultural price policy	175	72.92	I
2.	Poor economic condition	153	63.75	II
3.	Discrimination in payment of wages	153	63.75	II
4.	Lack of credit	137	57.08	III
5.	Costly agricultural inputs	119	49.58	IV
6.	Difficulty in getting loans	86	35.83	V
7.	Unavailability of subsidy on inputs	83	34.58	VI
III.	**Technological/ on farm constraints**			
1.	Non access to gender friendly technologies	179	74.58	I
2.	Lack of technical knowledge about improved farming activities	177	73.75	II
3.	Unavailability of inputs at right time and right quantities	168	70.00	III
4.	Unavailability of farm machinery at right time	167	69.58	IV
5.	Lack of Information and Communication Technologies	164	68.33	V
6.	Lack of awareness about gender friendly technologies	159	66.25	VI
7.	Lack of training programmes	144	60.00	VII
8.	Poor or non-access to information sources	144	60.00	VII
9.	Lack of irrigation	135	56.25	VIII
10.	Scarcity of labour	133	55.42	IX
11.	Small size of landholding	122	50.83	X
12.	Inadequate extension services	117	48.75	XI
13.	Lack of direct extension contact	94	39.17	XII
14.	Diminishing support from government for farm women	86	35.83	XIII
15.	Qualitative degradation of inputs	53	22.08	XIV

‘Dependency on others’ (rank VI) was perceived as a constraint by 63.33 per cent of farm women. Farm women were subjected to subordination at home as males were head of the households. Furthermore, women with lower levels of education had to rely on others for financial transactions. Women depended on men for tasks which exert more physical strength. Traditional mindset prevailing in society restricts social participation of women which further forces them to be dependent on others. ‘Secondary status in decision making’ (rank VII) was experienced by 57.92 per cent of farm women. Women’s thoughts and decisions were often dismissed by other family members. Despite the fact that women manage all household affairs, their decisions were simply considered for a second opinion only with a preconception that they were not deemed to be of high quality or appropriate for the situation due to various reasons like their lack of education and awareness of external events.

‘Health problems’ (rank VIII) was experienced by 45.83 per cent of farm women. Farm women reside in rural areas where adequate health care facilities might not be easily accessible. Women generally have several responsibilities at home and on the farm, leaving them with little time to care for their health. Women sometimes suffer from health problems as a result of exhausting work at home and strenuous physical strain by work on the farm. ‘Lack of decision making power’ (rank IX) was experienced by 42.08 per cent of farm women. As a gesture of protection, women were frequently dominated by other family members and decisions were made on their behalf, particularly for young and elderly women. Women were denied autonomy in various financial and familial matters and they often lacked decision making power wherein final decision making authority was vested with the elders.

‘Lack of adequate time to work on farm due to domestic work’ (rank X) was experienced by 40 per cent of farm women. Along with working on the field, farm women must also manage domestic work, children raising and elderly care and household affairs. Many farm women have less support and assistance from other family members, resulting in insufficient time to carry out farm tasks. ‘Low self-confidence’ was ranked eleventh in socio-personal constraints and was experienced by 37.50 per cent of farm women. Farm women viewed themselves to have less awareness and knowledge and had low self-confidence due to lack of proper education and higher social participation.

‘Family and social conflict’ was ranked twelfth in socio-personal constraints and was experienced by 35 per cent of farm women. Some of the farm women experienced familial conflicts due to varied reasons like male dominance and disagreements between family members about various farm and financial affairs. They also encountered difficulty in a few occasions as a result of their social position. ‘Discouraging agricultural price policy’ (rank I) was perceived to be major economic constraint by 72.92 per cent of farm women. The majority of farm women thought agricultural pricing was unremunerative and unsatisfactory because most of them had marginal or small land holdings and the crop harvested from these holdings was limited and the income earned on the farm was insufficient to meet all of the farm women family needs.

‘Poor economic condition’ (rank II) was perceived to be major economic constraint by 63.75 per cent of farm women. Majority of farm women had marginal and small land holdings and a moderate level of income from varied sources. Farm women believed that they lacked the financial resources to expand their farming operations and invest in other sources of revenue and their poor financial situation prevented their children from pursuing higher education. ‘Discrimination in payment of wages’ (rank II) was perceived to be one of the major economic constraints by 63.75 per cent of farm women. In farm operations, men and women were paid differently for the same type of work for same duration of time because women were prejudiced to be less productive. As a result, farm women frequently experienced disparity in payment of wages as men were paid more than women.

‘Lack of credit’ (rank III) was perceived to be major economic constraint by 57.08 per cent of farm women. Most farm women sought financial credit for domestic and agricultural purposes due to their poor socioeconomic status. They frequently struggled to obtain loans for farm activities due to a shortage of sources of finance lending institutions at lower interest rates. ‘Costly agricultural inputs’ (rank IV) was perceived to be major economic constraint by 49.58 per cent of farm women. As most farm women had poor economic background, their purchasing powers was limited and were not able to afford agricultural inputs such as seed, fertilizers and pesticides which they thought to be expensive. ‘Difficulty in getting loans’ (rank V) was experienced by 35.83 per cent of farm women. Due to lengthy procedural formalities, small and marginal land holdings and illiteracy, farm women experienced difficulty in getting loans. 'Unavailability of subsidy on inputs' (rank VI) was experienced by 34.58 per cent of farm women. Farm women were not able to afford farm inputs owing to their poor economic level. As subsidy was unavailable for all farm inputs, they were forced to forego some critical inputs.

'Non access to gender friendly technologies' (rank I) was perceived to be major technological/on farm constraint by 74.58 per cent of farm women. Due to the fact that the majority of farm women live in rural regions and have limited access to extension services compared to male farmers, gender-friendly tools and technologies were not accessible to them. As the majority of agricultural operations needed a lot of physical strength which was difficult for farm women, the lack of gender-friendly technologies in their immediate vicinity was a big constraint to their farm performance. 'Lack of technical knowledge about improved farming activities' (rank II) was perceived to be major technological/on farm constraint by 73.75 per cent of farm women. Farm women had moderate extension contact and had less knowledge about improved farming practices due to less exposure to capacity building programmes. 'Unavailability of inputs at right time and right quantities' (rank III) was perceived to be major technological/on farm constraint by 70 per cent of farm women. Due to increased demand, most farm women encountered lack of farm inputs for purchase before the start of the cropping season. They also experienced shortage of farm machinery for critical farm activities. 'Unavailability of farm machinery at right time' (rank IV) was perceived to be major technological/on farm constraint by 69.58 per cent of farm women. Farm machinery availability shortages during critical stages of crop had a significant impact on farm operations and farm women who did not own farm machinery had to pay more on engaging farm machines. 'Lack of Information and Communication Technologies' (rank V) was perceived to be major technological/on farm constraint by 68.33 per cent of farm women. As majority of agricultural families live in rural areas in addition to most farm women being uneducated, they were unable to use ICTs to learn about new technology.

'Lack of awareness about gender friendly technologies' (rank VI) was perceived to be major technological/on farm constraint by 66.25 per cent of farm women. As a result of illiteracy and insufficient extension services, farm women had little or no awareness about various available gender friendly tools and technologies. 'Lack of training programmes' (rank VII) was perceived to be major technological/on farm constraint by 60 per cent of farm women. Farm women perceived a dearth of training programmes that were tailored to their specific needs and timely requirements as women and owners of small farms. 'Poor or non-access to information sources' (rank VII) was perceived to be major technological/on farm constraint by 60 per cent of farm women. Illiteracy of farm women coupled with a lack of active social participation and inadequate access to extension services resulted in a scarcity of information about new farm technologies which ultimately obstructed higher yields on farms.

'Lack of irrigation' (rank VIII) was perceived to be major technological/on farm constraint by 56.25 per cent of farm women. Poor irrigation sources resulted in poorer yields and decreased farm income, making it difficult for farm women to make ends meet. 'Scarcity of labour' (rank IX) was perceived to be major technological/on farm constraint by 55.42 per cent of farm women. Due to migration of agricultural labour from rural areas to urban areas for better sources of livelihood, labour shortage was experienced specifically in peak crop seasons which resulted in delays in conducting critical farm tasks on time. 'Small size of land holding' (rank X) was perceived to be major technological/on farm constraint by 50.83 per cent of farm women. The size of the land holding had a huge impact on how different technologies were used on the farm and income from smaller land holdings was limited which was a major constraint to many farm women.

'Inadequate extension services' (rank XI) was perceived to be major technological/on farm constraint by 48.75 per cent of farm women. Many farm women had less access to extension services, particularly during peak crop seasons and also because extension service providers focused more on male farmers than farm women. 'Lack of direct extension contact' (rank XII) was experienced by 39.17 per cent of farm women. Extension service providers mostly focus on farmers as a whole, with farm women sometimes being left out and neglected. Due to their lower social participation, they lacked direct extension contact in the majority of situations and had to rely on their male counterparts for agricultural information.

'Diminishing support from government for farm women' (rank XIII) was experienced by 35.83 per cent of farm women. Farm women believed that the government gave little or no financial assistance and farm women oriented capacity building initiatives as well as specific marketing facilities for their produce were not adequate. 'Qualitative degradation of inputs' (rank XIV) was experienced by 22.08 per cent of farm women. Few farm women experienced low quality farm inputs specifically seeds. With much difficulty credit needed for farm inputs was gathered and when inputs quality was degraded, farm women not only experienced monetary loss but also missed critical time for certain farm operations.

As major contributors on farm alongside men, farm women expressed suggestions to overcome the constraints faced by them. Suggestions were ranked in the descending order of the frequencies obtained and were depicted in table 2. Farm women suggested 'increasing access to gender friendly technologies (74.58%, rank I), 'intensification of farm women centered government schemes and programmes' (70.00%, rank II), 'provision of financial support to take up income generating activities for women (67.08%, rank III), providing remunerative prices for farm produce (62.50%, rank IV), organizing capacity building programmes for farm women (60.00%, rank V), provision of subsidy on inputs (59.58%, rank VI), low interest loans for farming (53.75%, rank VII), creating legal awareness for benefit of women (47.50%, rank VIII), intensification of farm women focused extension services (45.00%, rank XI) and improving transportation facilities for marketing of produce (38.75%, rank X) for overcoming their constraints.

Similar findings were reported by Bandode (2012), Machhliya (2014), Rani (2014) and Imam (2019).

Farm women might have experienced difficulty in performing farm operations due to heavy farm tools and implements. Women who might not have proficiency to use the farm machinery might have resorted to manual work for possible farm activities. Increased access to gender friendly tools and technologies might reduce the burden of heavy work on farm and would increase the farm women's efficiency. Farm women might be expecting more farm women centered programmes which would aid them in providing finance, access to information and better marketing facilities. Farm women might be motivated in raising their standard of living by earning higher income through various avenues wherein they lacked initial financial investment and sincerely hoped for external financial support. Farm women who were majorly owners of marginal and small land holdings might have perceived that increased remunerative prices for produce would increase profits on their farms. Farm women were motivated towards building up of knowledge and skill to perform more efficiently in farm activities, thereby increasing their farm returns.

Table 2. Suggestions of farm women to overcome their constraints

S. No.	Suggestions	F	%	Rank
1.	Increasing access to gender friendly technologies	179	74.58	I
2.	Intensification of farm women centered government schemes and programmes	168	70.00	II
3.	Provision of financial support to take up income generating activities for women	161	67.08	III
4.	Providing remunerative prices for farm produce	150	62.50	IV
5.	Organizing capacity building programmes for farm women	144	60.00	V
6.	Provision of subsidy on inputs	143	59.58	VI
7.	Low interest loans for farming	129	53.75	VII
8.	Creating legal awareness for benefit of women	114	47.50	VIII
9.	Intensification of farm women focused extension services	108	45.00	IX
10.	Improving transportation facilities for marketing of produce	93	38.75	X

Farm women wherein most of them were of poor economic background had perceived that availability of subsidy on inputs could reduce their financial burden. Low interest loans by various finance institutions could aid farm women to avoid distress sale and also they would be able to afford inputs for farm activities and family needs. Empowered farm women who had greater interest in legal aspects had perceived that woman should be provided legal awareness in order to fight the injustice and discrimination they faced in male dominated society. Increased extension services could increase access to capacity building programmes and information sources which would lead to more awareness, dissemination and adoption of improved technologies. Farm women wherein most of them reside in rural areas faced difficulty in marketing of produce due to lack of proper transportation facilities to better markets.

Many of the constraints experienced by farm women could be eliminated or their magnitude can be decreased by adequate interventions at family and societal level. Encouraging access to education for women will provide a farm woman with more decision making power and boosts their self-confidence. It also empowers farm women to be self-reliant and have control over their earnings. In addition to boosting farm women's access to extension services, extension workers should focus on wider diffusion of gender-friendly technologies and increasing access to gender-friendly technologies to improve farm women's productivity. Emphasis on increasing the favourable attitude of farm women towards improved agricultural technologies would render higher income even on smaller sized farms, improving the living conditions of farm women's families. Farm women should be given more prominence in government support for farmers in order to keep the empowered women working in agriculture.

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CONSTRAINTS IN GREENHOUSE CROP PRODUCTION IN CHITTOOR DISTRICT OF ANDHRA PRADESH, INDIA

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ABSTRACT

An attempt has been made to study constraints faced by the greenhouse farmers in Chittoor district. For this purpose, five mandals were selected based on highest average number of greenhouses. The data were collected from each respondent through personal interview method with the help of structured questionnaire during 2019-20. Garrett ranking technique was employed to analyze each of the constraints affecting the adoption of greenhouse technology. To sustain the self-sufficiency in food production we need effective technologies, which can improve the productivity and sustainability of our major farming systems. Greenhouse technology, one among improved technologies that ensures stability in agriculture production.

KEYWORDS: Greenhouse, factors, Environmental constraints.

INTRODUCTION

Protected cultivation also sometimes called as greenhouse cultivation. In the present situation of everlasting demand for enhanced quality horticultural crops and continuously lessening land holdings, greenhouse technology is the finest choice for efficient use of land and other resources. Crop yields can be numerous times higher than those under open field conditions, greater quality, higher input use efficiencies are realized and export can be heightened.

With the innovation in agriculture, various types of protected cultivation practices appropriate for a specific type of agro-climatic zone have materialized. Among these protective cultivation practices, Glasshouse, Green house, Plastic house/ Greenhouse, Lath house, Cloth house, Net house, shade house, cold frames and hot beds etc. is useful for the Indian conditions.

In Indian Horticulture, there is significant increase in production of horticultural produces with a total amount of more than 311.71 million tonnes and India ranks second in horticultural production in world next to China (NHB, 2018). In spite of second largest producing country there is low productivity in India which is due to the adverse climatic conditions like varying range of temperature from 0-48^{0}C during the year which does not allow year round cultivation of vegetable in open condition. Availability of large quantity produce in market during growing season. Day by day there is increasing in demand for high quality vegetables and availability of vegetables round the year, which can either be fulfilled by early and late cultivation or off-season cultivation adopting protected cultivation. Presently, progressive farmers are adopting commercial protected cultivation of high value vegetables and flowers (Maitra, 2020).

MATERIAL AND METHODS

Chittoor district will be purposively selected on the basis of predominance of greenhouses. Proportionate random sampling will be used in selecting the greenhouses located in various mandals of the district. 30 greenhouse units will be selected for study. Major crops cultivated under greenhouse units‑were selected for the study. Primary data will be collected for the agricultural year 2019-20 through personal interview with the help of a well-structured schedule formulated based on objectives. It includes establishment costs of greenhouses, material and labour resources used , costs and returns of greenhouse crops, factors influencing production and marketing of greenhouse crops and problems experienced by greenhouse farmers. Garrett ranking technique was employed to analyze the data and arrive at valid conclusions

RESULTS AND DISCUSSION

In the present study, some of the important constraints faced by greenhouse farmers in production of capsicum

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and chrysanthemum crops of Chittoor district was studied in the following sub-heads.

Environmental Constraints

The environmental constraints faced by farmers in adoption of greenhouse technology were presented in Table 1. The constraint faced by farmers under the environmental constraints is the relatively higher perishable flowers/vegetables (75.30%) and i ranked in first position. The perishable nature of produce from the greenhouses demands immediate disposal into the markets. Otherwise the quality of produce is deteriorated. Occurrence of pest and diseases was ranked second (67.50%). Due to more incidence of pest and diseases inside the greenhouses exceeds relatively more to open cultivation because of high moisture and high humidity inside the greenhouse. Occurrence of physiological disorders ranked third position (55.16%), followed by highly fluctuating weather conditions under greenhouse (52.80%), Scarcity of water for irrigation under greenhouse (36.93%), poor drainage of soils (36.00%), due to irrigation through drip inside the greenhouse has led to poor drainage conditions. and low fertility status of soil was ranked VII Seventh (26.30%). The results are similar to Paroda (2013) who reported that among the major environmental constraints in production of horticultural crops in India are temperature, duration and quality of sunlight, surplus or scarcity of water, atmospheric moisture, weeds, physiological disorders, heavy winds, carbon dioxide and incidence of pest and diseases.

Table 1. Environmental constraints as faced by farmers in adoption of greenhouse technology

S. No.	Constraints	Total Garratt score	Percentage	Rank
1.	Relatively higher perishability of flowers/ vegetables	2259	75.30	I
2.	Occurrence of pest and diseases	2025	67.50	II
3.	Occurrence of physiological disorders	1655	55.16	III
4.	Highly fluctuating weather conditions	1584	52.80	IV
5.	Scarcity of water for irrigation under greenhouse	1108	36.93	V
6.	Poor drainage of soil	1080	36.00	VI
7.	Low soil fertility status	789	26.30	VII

Technical Constraints

High knowledge and skill intensive technology are prerequisites for greenhouse technology. The various technical constraints faced by greenhouse farmers were presented in Table 2. Farmers expressed that the non-availability of quality poly house equipment's at local market was ranked first (79.20%), followed by non-availability of quality inputs like pesticides and insecticides at right time (64.80%), difficulty in following the package of practices for cultivation of crops under greenhouse (53.86), lack of guidance about the production techniques (53.70%), non-availability of quantity and quality planting material at right time (52.46%), lack of scientific knowledge about crop production under poly house (43.96%), lack of relevant literature in local languages (28.40%), and limited and irregular power supply (23.60%), is ranked least among the technical constraints as the required power is being supplied to the greenhouse farmers. The results are in conformity with the results obtained by Manjunath *et al*. (2015) where in it was reported that availability of quality seed and planting material of required cultivar is a severe constraint faced by farmers on account of increased dependence on formal sector especially private seed companies. Similar results are also reported by Singh and Sirohi (2006) where in it was reported that no specific breeding work had been initiated for development of suitable varieties for protected cultivation even in important vegetables, viz., tomato, cherry tomato, sweet pepper and cucumber.

Table 2. Technical constraints as faced by farmers in adoption of greenhouse technology

S. No.	Constraints	Total Garratt score	Percentage	Rank
1	Non-availability of quality poly house equipment's at local market	2376	79.20	I
2	Non-availability of quality inputs like pesticides and insecticides at right time	1944	64.80	II
3	Difficulties in following there commended practices	1616	53.86	III
4	Lack of technical guidance about production techniques	1611	53.70	IV
5	Non-availability of required quantity and quality planting material at right time	1574	52.46	V
6	Lack of scientific knowledge about crop production under poly house	1319	43.96	VI
7	Lack of relevant literature in local language	852	28.40	VII
8	Limited and irregular power supply	708	23.60	VIII

Labour Constraints

Greenhouse cultivation of crops demands skilled labour and intensive labour throughout the year. Availability of skilled labour is a major issue due to migration from rural to urban areas in search of better employment opportunities and indifferent attitude of youth towards agriculture has led to shortage of skilled labour and which has naturally raised the wage rates of skilled labour required for greenhouse cultivation. The labour constraints faced by farmers were presented in Table 3. Scarcity of labour during peak season was ranked first (63.30%), followed by high cost of skilled labour (53.80%) and lack of availability of skilled labour (32.90%). The results are in conformity with the findings of Prabhakar *et al.* (2017).

Table 3. Labour constraints as faced by farmers in adoption of greenhouse technology

S. No.	Constraint	Total Garratt score	Percentage	Rank
1	Scarcity of labour during peak seasons	1899	63.30	I
2	High cost of skilled labour	1614	53.80	II
3	Lack of availability of skilled labour	987	32.90	III

Economic Constraints

The economic constraints faced by the greenhouse farmers in adoption of greenhouse technology were presented in Table 4. High initial investment in construction of poly house was ranked first (80.60%), as the initial investment required to establish a greenhouse is very high and is beyond the reach of small and marginal farmers. Singh and Sirohi (2006) also reported that the basic cost of fabrication and the operation cost of the climate-controlled greenhouses are very high.

The farmers expressed that it took minimum of 8 months after submission of loan application, to avail loans facilities from financial institutions and commercial banks and hence complexity of loan procedure is ranked second (67.06%), poor accessibility of credit was ranked third (54.46%), followed by lack of adequate and timely disbursement of loan from financial institutions (53.66%), high cost of planting material (50.86%), lack of awareness about credit and subsidy facilities (46.60%), absence of crop insurance scheme for flowers and vegetables (39.43%), high cost of plant protection chemicals (29.66%), and high cost of transportation (27.06%). Greenhouse cultivation of crops requires quality-planting material, inputs etc, which adds economic burden to the farmers and the upper ceiling limit of subsidy, varies from scheme to scheme but generally it ranged from 20 to 50 percent of the cost of erection of greenhouse.

Table 4. Economic constraints as faced by farmers in adoption of greenhouse technology

S. No.	Constraint	Total Garratt score	Percentage	Rank
1	High initial investment in construction of poly house	2418	80.60	I
2	Complexity of loan procedure	2012	67.06	II
3	Poor accessibility to subsidy	1637	54.56	III
4	Lack of adequate and timely disbursement of loan from financial institutions	1608	53.66	IV
5	High cost of planting material	1526	50.86	V
6	Lack of awareness about credit and subsidy facilities	1398	46.60	VI
7	Absence of crop insurance scheme for flowers and vegetables	1183	39.43	VII
8	High cost of plant protection chemicals	890	29.66	VIII
9	High cost of transportation	828	27.60	IX

Table 5. Marketing constraints as faced by farmers in adoption of greenhouse technology

S. No.	Constraint	Total Garratt score	Percentage	Rank
1	Fluctuation in market prices	2340	78.00	I
2	Existence of middlemen malpractices	1926	64.20	II
3	Lack of marketing facilities at local place(block/district headquarters)	1634	54.46	III
4	Lack of exclusive markets for flowers/ vegetable grown under greenhouse	1584	52.80	IV
5	Lack of specialized supply chain management including cold chain	1182	39.40	V
6	Distress sale due to immediate need of money	1017	33.90	VI
7	Difficulty in grading the produce at the production level	817	27.23	VII

Marketing constraints

The marketing constraints faced by the greenhouse farmers in adoption of greenhouse technology were presented in Table 5. Fluctuations in market prices was ranked first (78.00%), followed by existence of middlemen malpractices (64.20%), lack of marketing facilities at local place (54.46%), lack of exclusive markets for vegetables/flowers grown under greenhouse (52.80%), lack of specialized supply chain management including cold chain (39.40%), distress sale due to immediate need of money (33.90%), and difficulty in grading the produce at production level (27.23%). The deficiencies in the infrastructure such as poor grading, transport facilities and cold chain management combined with malpractices were added to the risk component of the greenhouse farmers.

CONCLUSION

While analyzing overall constraints faced by the greenhouse respondents, it was found that higher perishability of flowers and vegetables, non-availability of quality poly house equipment's at local market, scarcity of labour during peak season, high initial investment in greenhouse establishment and fluctuations in greenhouse crops prices were the major constraints faced by greenhouse farmers in study area.

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EFFECT OF PLANT GEOMETRY AND NITROGEN LEVELS ON YIELD, NUTRIENT UPTAKE AND POST HARVEST SOIL AVAILABLE NUTRIENT STATUS OF BROWNTOP MILLET UNDER SOUTHERN AGRO-CLIMATIC ZONE OF ANDHRA PRADESH

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ABSTRACT

A field experiment was conducted at S.V. Agricultural College Farm, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India during *kharif* season of 2020 to analyze the yield, nutrient uptake and post-harvest soil available nutrient status of browntop millet under varied plant geometry and nitrogen levels. The treatments include three plant geometry *viz*., P_1 (30 cm × 20 cm), P_2 (45 cm × 20 cm) and P_3 (60 cm × 20 cm) and four nitrogen levels, *viz*., 20 kg N ha^{-1} (N_1), 40 kg N ha^{-1} (N_2), 60 kg N ha^{-1} (N_3) and 80 kg N ha^{-1} (N_4). Plant geometry P_2 resulted in significantly highest grain yield but it was statistically on par with P_3 and significantly superior straw yield was recorded with P_1 plant geometry.[Uptake of higher nitrogen and potassium was recorded with P_2 and P_1 plant geometry respectively with no significant disparity among P_1, P_2 and P_3, while phosphorus uptake was recorded higher with P_3 plant geometry which was on par with P_2. Significantly lower amount of post harvest soil available nutrients were observed in P_3 plant geometry which was on par with P_2. Among the nitrogen levels tested, application of 60 kg N ha^{-1} produced higher grain yield which was on par with application of 80 kg N ha^{-1}, higher straw yield and nutrient uptake was recorded with 80 kg N ha^{-1} but it was statistically comparable with 60 kg N ha^{-1}.]

KEYWORDS: Browntop millet, nutrient uptake, plant geometry, nitrogen levels and post-harvest soil available nutrients.

INTRODUCTION

Browntop millet (*Brachiaria ramosa* (L.) Stapf. or *Urochloa ramosa* (L.) R.D. Webster) is an annual hardy, heat and drought tolerant minor millet crop that grows to a height of 90 to 150 cm. Unlike other millets, brown-top millet has a unique quality as it can be grown in the partial shade which ensures wider choice of adoption even in fruit orchards or in agro-forestry system. Crop matures early approximately 75-90 days. It is known for its rapid forage production (hardly 50 days duration) act as a cover crop in plantation crops for soil erosion control and for high straw production. 100 grams of browntop millet contains 8.98, 1.89, 3.90, 8.20 and 71.32 per cent of protein, fat, minerals, crude fiber and carbohydrates respectively.

Low productivity in browntop millet is a major problem due to lodging during *kharif* normally when it is sown at closer spacing or broadcasting. The productivity of brown top millet can be increased by applying of fertilizers at optimum dose, especially nitrogen is required for initial establishment, vigorous and robust tillers with broad leaves which enhances the quality and productivity of grain. Therefore, the optimum plant geometry and nitrogen management provides favourable environmental conditions to the crop during various growth and developmental stages, resulting in better performance and enhanced productivity of browntop millet.

MATERIAL AND METHODS

The present field experiment was carried out at dryland farm, S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University. The experiment was laid out in a random block design with factorial concept with twelve treatment combinations and replicated thrice. The treatments include three plant geometry *viz*., P_1 (30 cm × 20 cm), P_2 (45 cm × 20 cm) and P_3 (60 cm × 20 cm) and four nitrogen levels, *viz*., 20 kg N ha^{-1} (N_1), 40 kg N ha^{-1} (N_2), 60 kg N ha^{-1} (N_3) and 80 kg N ha^{-1} (N_4). The experimental field was sandy loam in texture which is low in organic carbon (0.38%). The soil is alkaline in reaction (pH 7.7), low in available N (151.0 kg ha^{-1}), medium in available phosphorus (207.0 kg ha^{-1}) and potassium (34.0 kg ha^{-1}). The variety of browntop millet

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tested was GPUBT-6. A total rainfall of 859.0 mm was received in 33 rainy days during the crop growing period. Recommended dose of fertilizers was 40-20-20 kg N, P_2O_5 and K_2O ha^{-1}. The nutrients were applied in the form of urea, single super phosphate and muriate of potash. Available soil nitrogen (N) was estimated by the method described by Subbiah and Asija (1956) and the nitrogen status was expressed in kg ha^{-1}. Soil available phosphorus was determined as described by Olsen *et al*. (1954) using spectrophotometer and expressed in kg ha^{-1}. Soil available Potassium was estimated by neutral normal ammonium acetate extraction method using Flame Photometry (Jackson, 1973) and expressed in kg ha^{-1}.Plants from each treatment in the plot were selected at random and tagged for taking the observation *viz*, nutrient uptake of NPK. The oven dried samples of plants material were ground in a willey mill and analyzed for N, P and K contents. The nitrogen, phosphorus and potassium uptake were calculated by multiplying the nutrient content of the plant sample with corresponding total dry matter and expressed in kg ha^{-1}. The total nitrogen content in the plant sample was estimated by the Micro Kjeldal method as suggested by (Association of Official Agricultural Chemists (AOAC), 1960). The total phosphorus content in the plant sample was estimated with vanado-molybdo phosphoric acid method by Jackson (1973). The total potassium content in the plant sample was estimated with triple acid digestion method using Flame Photo Meter as suggested by Jackson (1973). The data collected were analyzed statistically following the procedure given by Panse and Sukhatme (1985) wherever the treatmental differences were significant, critical differences were worked out at five per cent probability level. Treatment differences that were not significant are denoted as NS.

RESULTS AND DISCUSSION

Grain yield

Grain yield of browntop millet varied significantly due to plant geometry as well as nitrogen levels tried, while the interaction effect was found to be non significant.

The highest grain yield of browntop millet was realized with plant geometry P_2 (45 cm × 20 cm) which was statistically on par with that of P_3 (60 cm × 20 cm). This might be due to optimum plant geometry provided favourable microclimate which enables the individual plant in efficient utilization of growth resources like light, moisture and nutrients which in turn to achieve the maximum productivity. Even though all the yield attributes were maximum in wider plant geometry, panicles on late formed tillers were not attained full maturity there by reduced the grain yield per unit area when compared to optimum plant geometry. Whereas severe intra-plant competition and lodging at reproductive stage due to higher plant height might have negative effect on grain yield under closer plant geometry. The results were in confirmity with the findings of Natarajan *et al*. (2019) and Santosh *et al*. (2020).

Among nitrogen levels tested, higher grain yieldwas registered with the application of 60 kg N ha^{-1} (N_3) which was comparable with 80 kg N ha^{-1} (N_4) followed by 40 kg N ha^{-1} (N_2) which was in turn exhibited significant difference to both of them. Higher yield with increase in nitrogen level up to 60 kg N ha^{-1} (N_3) might be due to the reason that better availability and uptake of nutrients resulted in enhanced chlorophyll synthesis, leaf area, photosynthetic efficiency, better growth and dry matter production which ultimately led to efficient partitioning and translocation of photosynthates from source to sink. Application of 80 kg N ha^{-1} (N_4) resulted in more vegetative growth which in turn reduced the grain yield when compared to 60 kg N ha^{-1} (N_3). Significantly lower grain yield was noticed with 20 kg N ha^{-1} (N_1). The present results are in accordance with the findings of Vimalan *et al*. (2019) and Anitha *et al*. (2020).

Straw yield

Varied plant geometry and nitrogen levels exerted significant influence on the straw yield of browntop millet, while their interaction effect was found to be non significant.

Significantly higher straw yield was recorded at P_1 (30 cm × 20 cm) than that of P_2 (45 cm × 20 cm). This might be due to closer plant geometry which resulted in taller plants with high dry matter and more plant population per unit area and ultimately increased the straw yield. These results were in accordance with the findings of Mane *et al*. (2019) and Sanjay *et al*. (2021). The lower straw yield was observed with the P_3 (60 cm × 20 cm) plant geometry which was statistically differed from other plant geometry tried.

Under varied nitrogen levels tested, straw yieldwas significantly higher with the application of 80 kgNha^{-1} (N_4) which was comparable with 60 kg N ha^{-1} (N_3)

Table 1. Grain yield, straw yield (kg ha^{-1}) and harvest index (%) as influenced by varied plant geometry and nitrogen levels in browntop millet

Treatments	Grain yield	Straw yield	Harvest index
Plant Geometry			
P_1: 30 cm × 20 cm	1353	5262	20.3
P_2: 45 cm × 20 cm	1548	4663	24.8
P_3: 60 cm × 20 cm	1470	4294	25.4
SEm±	36.9	119.2	0.59
CD (P = 0.05)	108	350	1.7
Nitrogen levels			
N_1: 20 kg ha^{-1}	1075	4047	21.1
N_2: 40 kg ha^{-1}	1427	4616	23.7
N_3: 60 kg ha^{-1}	1682	5041	25.1
N_4: 80 kg ha^{-1}	1643	5254	23.9
SEm±	42.6	137.7	0.68
CD (P = 0.05)	125	404	2.0
Interaction			
SEm±	75.6	238.4	1.18
CD (P = 0.05)	NS	NS	NS

followed by 40 kg N ha^{-1} (N_2) which in turn statistically not comparable with 60 kg N ha^{-1} (N_3). The increased dose of nitrogen leads to higher availability of nitrogen along with enhanced absorption of other nutrients. Nitrogen plays a key role in the synthesis of chlorophyll and higher availability of nitrogen tends to increase leaf area, plant height, number of tillers and dry matterdue to higher photosynthetic efficiency ultimately increased growth and straw yield. The similar results were reported by Prabudoss *et al*. (2017) and Saikishore *et al*. (2020). Significantly lower straw yield was noticed with 20 kg N ha^{-1} (N_1).

Nutrient uptake

Nutrient uptake of browntop millet differed significantly due to varied plant geometry and nitrogen levels, while the interaction effect found to be non significant.

Nitrogen uptake was higher with plant geometry P_2 (45 cm × 20 cm) which was comparable with P_3 (60 cm × 20 cm) and P_1 (30 cm × 20 cm)plant geometry. Phosphorus uptake was higher in wider plant geometry P_3 (60 cm × 20 cm) which was statistically superior to P_1 (30 cm × 20 cm) but was on par with that of P_2 (45 cm × 20 cm). Lower uptake of nitrogen and phosphorus was noticed with P_1 (30 cm × 20 cm) plant geometry. Whereas potassium uptake was higher with P_1 (30 cm × 20 cm) plant geometry which was statistically on par with that of P_2 (45 cm × 20 cm) and P_3 (60 cm × 20 cm) plant geometry. Lower potassium uptake was noticed with P_3 (60 cm × 20 cm). The difference in uptake of potassium was might be due to higher per cent of potassium content in straw. These findings were in conformity with Natarajan *et al*. (2019) and Thakur *et al*. (2019).

Table 2. Nutrient uptake (kg ha^{-1}) and post-harvest soil available nutrient status (kg ha^{-1}) at harvest as influenced by varied plant geometry and nitrogen levels in browntop millet

Treatments	Nitrogen uptake	Phosphorous uptake	Potassium uptake	Soil available nitrogen	Soil available phosphorous	Soil available potassium
Plant Geometry						
P_1: 30 cm × 20 cm	64	28.4	109	113	19.4	154
P_2: 45 cm × 20 cm	69	31.0	106	106	16.7	147
P_3: 60 cm × 20 cm	67	32.3	102	101	14.8	142
SEm±	2.0	1.08	3.8	2.7	0.46	3.7
CD (P = 0.05)	NS	3.2	NS	8	1.3	11
Nitrogen levels						
N_1: 20 kg ha^{-1}	47	21.6	75	101	26.1	166
N_2: 40 kg ha^{-1}	64	29.3	103	104	18.4	153
N_3: 60 kg ha^{-1}	75	34.1	118	109	13.8	140
N_4: 80 kg ha^{-1}	80	37.2	127	113	9.6	131
SEm±	2.3	1.25	4.4	3.1	0.53	4.3
CD (P = 0.05)	7	3.7	13	9	1.5	13
Interaction						
SEm±	4.0	2.16	7.6	5.4	0.91	7.4
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Uptake of nutrients was maximum with application of 80 kg N ha^{-1} (N_4) which was on par with 60 kg N ha^{-1} (N_3) followed by 40 kg N ha^{-1} (N_2) which was inturn significant difference to that of later one. The growth and yield of crop was determined by the presence and availability of nutrients in the soil for uptake. Uptake of nutrients depends on the concentration of ions in the available form in the external medium. Increased levels of nitrogen might be increased the availability of nitrogen ions in the soil solution resulted in higher absorption of P and K along with nitrogen. Similar findings were also observed by Jyothi *et al.* (2016) and Vimalan *et al.* (2019). Significantly lower nutrient uptake was noticed with 20 kg N ha^{-1} (N_1).

Post-harvest soil available nutrient status

Varied plant geometry and nitrogen levels have exerted significant influence on the post harvest soil nutrient status (available nitrogen, phosphorus and potassium), while the interaction effect was not statistically traceable.

Post-harvest soil available nitrogen and potassium were higher with P_1 (30 cm × 20 cm) plant geometry which was however on par with that of P_2 (45 cm × 20 cm followed by P_3 (60 cm × 20 cm) which inturn on par with that of P_2 (45 cm × 20 cm). The highest post-harvest soil available phosphorous was noticed with P_1 (30 cm × 20 cm) followed by P_2 (45 cm × 20 cm) with significant disparity between them. This might be due to higher uptake of nutrients by browntop millet in wider plant geometry resulted in lower available nitrogen and potassium in the soil after harvest. Lower post-harvest soil available nitrogen, phosphorous and potassium were recorded with P_3 (60 cm × 20 cm). This might be due to large root system in wider plant geometry helped in better absorption of nutrients which in turn exhibited more number of tillers with increased leaf area plant^{-1}.

Post-harvest available soil nitrogen was higher with application of 80 kg N ha^{-1} (N_4) and lower with 20 kg N ha^{-1} (N_1). The difference might be due to increase in nitrogen levels which resulted in overall growth and yield of crop with well developed root system by releasing root exudates helps in mineralization of organic nitrogen by microorganisms, ultimately increase in available nitrogen status of the soil. The highest post-harvest soil available phosphorous and potassium availability were registered with 20 kg N ha^{-1} (N_1) and significantly lower were noticed with application 80 kg N ha^{-1} (N_4). With increase in nitrogen levels, phosphorous and potassium content in the soil after harvest was decreased. This might be due to the reason that higher uptake of phosphorus and potassium with increase in nitrogen level might have limited the availability phosphorous and potassium in the soil after harvest. The similar results were reported by Jyothi *et al*. (2016) and Anitha *et al*. (2020).

Finally, it can be concluded that higher grain yield of browntop millet could be achieved with plant geometry of 45 cm × 20 cm along with the application of 60 kg N ha^{-1}on sandy loam soils of Southern Agro-climatic Zone of Andhra Pradesh.

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EFFECT OF SOIL AND FOLIAR POTASSIUM FERTILIZATION ON GROWTH AND YIELD OF BLACKGRAM

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ABSTRACT

A field experiment was conducted at S.V. Agricultural College Farm, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India during *rabi*, 2021-22 to study the effect of soil and foliar potassium fertilization on growth and yield of blackgram. The treatments consists of three potassium levels as first factor *viz*., 20, 30, 40 kg K_2O ha^{-1} and five foliar sprays as second factor *viz*., no foliar spray, water spray at flowering and pod development stages, 0.5% KNO_3 at flowering and pod development stages, 1% KCl at flowering and pod development stages and 1% KH_2PO_4 at flowering and pod development stages imposed in a randomized block design with factorial concept and replicated thrice. Among the potassium levels tried, soil application of 40 kg K_2O ha^{-1} resulted in taller plants, higher drymatter production, seed yield and haulm yield, which was comparable with soil application of 30 kg K_2O ha^{-1}. Among different foliar sprays tried, tallest plants, higher drymatter, seed yield and haulm yield were recorded with application of 1% KH_2PO_4 at flowering and pod development stages, which was on par with 1% KCl and 0.5% KNO_3 at flowering and pod development stages.

KEY WORDS: Blackgram, Potassium, Growth and Yield.

INTRODUCTION

In India, blackgram is a major pulse crop grown in both *kharif* and *rabi* seasons, as a sole crop or intercrop or fallow crop. It is famous for its nutritional quality having rich protein (26.20%), carbohydrates (56.60%), fats (1.20%), minerals, vitamins, amino acids and phosphoric acid (Shashikumar *et al*., 2013). Blackgram is mostly grown 'on marginal and submarginal lands' without proper inputs and management practices. Imbalanced nutrition is one of the 'major cause for the lower productivity of blackgram. Potassium application is being neglected inspite of its requirement in larger quantities by the blackgram, which is leading to the depletion of soil potassium reserves. Potassium removal from the soil is as much as or higher than nitrogen but still its use in fertilizer is negligible for blackgram (Chaudhari *et al*., 2018). However, because of field level potassium 'responses and awareness' of soil K depletion under intensive cereal-pulse cropping systems, the importance of potassium fertilization has recently gained importance.

Foliar nutrition provides an excellent way for the absorption of nutrients as it can be applied directly to the site of metabolism through translocation of nutrients from leaves to all parts there by helping in synchronizing flowering as well as pod setting. It increases yield from 12.00 to 25.00 % and on the other side more than 90.00% of the fertilizer applied is utilized by the plant. (Pooja and Meena, 2020). Foliar feeding of nutrients minimizes environmental pollution by reducing the amount of fertilizers added to 'the soil and also enhances the yield and quality of produce.'

MATERIAL AND METHODS

A field experiment was conducted during *rabi,* 2021-22 at Wetland Farm of S.V. Agricultural College, Tirupati, Acharya N. G. Ranga Agricultural University which is located in the Southern Agro-Climatic Zone of Andhra Pradesh, at 13.5°N latitude and 79.5°E longitude and at an altitude of 182.9 m above the mean sea level. The soil of the experimental field was sandy loam in texture, neutral in reaction, low in organic carbon (0.21 %) and available nitrogen (172.9 kg ha^{-1}), medium in available phosphorus (29 kg ha^{-1}) and available potassium (193.4 kg ha^{-1}). The experiment was laid out in randomized block design with a factorial concept and replicated thrice. Treatments include three potassium levels *viz.,* 20 kg K_2O ha^{-1} (K_1), 30 kg K_2O ha^{-1} (K_2) and 40 kg K_2O ha^{-1} (K_3) as the first factor and five foliar sprays *viz.,* No foliar spray

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(F_1), Water spray at flowering and pod development stages (F_2), 0.5 % KNO_3 at flowering and pod development stages (F_3), 1% KCl at flowering and pod development stages (F_4) and 1% KH_2PO_4 at flowering and pod development stages (F_5), as the second factor. The crop was sown at 30 cm × 10 cm spacing with a seed rate of 25 kg ha^{-1}. The variety TBG-104 was sown on 23rd of October and recommended dose of the fertilizer 20 kg N : 50 kg P_2O_5 ha^{-1} was applied uniformly to all the treatments. All the other recommended practices were also adopted as per the crop requirement. The collected data were statistically analyzed following the analysis of variance for randomised block design with factorial concept as given by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Plant height and Leaf area index

At harvest, soil application of 40 kg K_2O ha^{-1} (K_3) recorded the highest plant height and leaf area index, which was on par with soil application of 30 kg K_2O ha^{-1} (K_2). Significantly lowest plant height was recorded with soil application of 20 kg K_2O ha^{-1} (K_1). Among the different foliar fertilization treatments, foliar application of 1% KH_2PO_4 at flowering and pod development stages (F_5) recorded the highest plant height and leaf area index, which was however comparable with foliar application of 1% KCl at flowering and pod development stages (F_4) and 0.5% KNO_3 at flowering and pod development stages (F_3) (Table 1). The plant stature and leaf area index was lower with no foliar spray (F_1), which was on par with water spray at flowering and pod development stages (F_2).

The increase in plant height with an application of potassium, either through soil or through foliar fertilization, could be attributed to the reason that potassium is known to augment cell division and cell expansion in plants by stimulating the biological activity of photosynthetic pigments and enzymes which in turn promotes the vegetative growth of the plant. These results are in line with Hussain *et al*. (2011) and Thalooth *et al*. (2006). Foliar application of nutrients at the hour of need might have enabled the plants to maintain high chlorophyll content, leaf area per plant and ultimately higher leaf area index

Dry matter production

With regard to the different potassium levels tried, the highest dry matter production was recorded with soil application of 40 kg K_2O ha^{-1} (K_3), followed by soil application of 30 kg K_2O ha^{-1} (K_2) with no significant difference between them. Significantly lowest dry matter production was recorded with soil application of 20 kg K_2O ha^{-1} (K_1).

Among the foliar sprays tried, the highest dry matter production was recorded with foliar application of 1% KH_2PO_4 at flowering and pod development stages (F_5), which was on par with foliar application of 1% KCl at flowering and pod development stages (F_4) and 0.5% KNO_3 at flowering and pod development stages (F_3). Significantly lowest dry matter production was noticed with no foliar spray (F_1), followed by water spray at flowering and pod development stages (F_2) (Table 1).

Nitrogen and potassium are synergistic with each other, that helps to improve nitrogen content and use efficiency, that aids in maintaining higher auxin levels in plant with soil and potassium fertilization, which in turn might have resulted in better plant height, leaf area and chlorophyll content. Increased plant height and leaf area might have resulted in a better interception, absorption and utilization of radiant energy, leading to a higher photosynthetic rate and ultimately higher accumulation of dry matter by the plants. The results are in line with those results observed by Shashikumar *et al*. (2013) in blackgram and Maheswari and Karthik (2017).

Seed yield

Among the different potassium levels, soil application of 40 kg K_2O ha^{-1} (K_3) recorded the highest seed yield, which was on par with soil application of 30 kg K_2O ha^{-1} (K_2). The seed yield of blackgram was significantly lowest with soil application of 20 kg K_2O ha^{-1} (K_1).

Foliar application of different potassium salts at flowering and pod development stages increased the seed yield over no foliar spray (F_1) and water spray at flowering and pod development stages (F_2). Among the different foliar sprays, the highest seed yield was recorded with foliar spray of 1% KH_2PO_4 at flowering and pod development stages (F_5), which was statistically on par with foliar spray of 1% KCl at flowering and pod development stages (F_4) and 0.5% KNO_3 at flowering and pod development stages (F_3). Significantly lowest seed yield of blackgram was recorded with no foliar spray (F_1), which was on par with water spray at flowering and pod development stages (F_2) (Table 1).

Table 1. Effect of soil and foliar potassium fertilization on growth and yield of blackgram

Treatments	Plant height at harvest (cm)	Leaf area index at harvest	Drymatter production at harvest (kg ha^{-1})	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Potassium levels (K)					
K_1 : 20 kg K_2O ha^{-1}	40.5	1.58	3616	1572	1682
K_2 : 30 kg K_2O ha^{-1}	43.3	1.94	3978	1702	1856
K_3 : 40 kg K_2O ha^{-1}	45.0	2.03	4130	1724	1884
SEm±	0.93	0.043	115.2	34.6	41.3
CD (P = 0.05)	**2.6**	**0.11**	**334**	**100**	**120**
Foliar nutrition (F)					
F_1 : No foliar spray	39.6	1.50	3492	1514	1695
F_2 : Water spray at flowering and pod development stages	40.1	1.53	3562	1557	1705
F_3 : KNO_3 @ 0.5 % at flowering and pod development stages	44.0	1.99	4016	1707	1871
F_4 : KCl @ 1 % at flowering and pod development stages	45.1	2.06	4174	1770	1876
F_5 : KH_2PO_4 @ 1 % at flowering and pod development stages	45.9	2.13	4295	1780	1891
SEm±	1.20	0.054	148.7	44.7	53.3
CD (P = 0.05)	**3.5**	**0.14**	**431**	**175**	**154**
Interaction (K × F)					
SEm±	2.08	0.094	257.5	77.4	92.3
CD (P = 0.05)	NS	NS	NS	NS	NS

The positive effect of soil and foliar potassium application on seed yield could be due to the availability of more potassium ions, which might have enhanced the photosynthesis process by activating ATPase enzyme, which plays a major role in photosynthesis and facilitated better partitioning of photosynthates, that led to increased growth and yield attributes and finally seed yield. These results were corroborated with the findings of Vekaria *et al*. (2013), Sakpal (2015) and Goud *et al*. (2014).

Haulm yield

The haulm yield of blackgram was significantly influenced by soil and foliar potassium fertilization, while the interaction effect was not statistically traceable.

With regard to the potassium levels tried, the highest haulm yield was recorded with soil application of 40 kg K_2O ha^{-1} (K_3), followed by 30 kg K_2O ha^{-1} (K_2) with no significant difference between them. Significantly lowest haulm yield was recorded with soil application of 20 kg K_2O ha^{-1} (K_1). Among the foliar sprays, the highest haulm yield was recorded with foliar application of 1% KH_2PO_4 at flowering and pod development stages (F_5), which was on par with foliar application of 1% KCl at flowering and pod development stages (F_4) and 0.5 % KNO_3 (F_3) at flowering and pod development stages. Significantly lowest haulm yield was noticed with no foliar spray (F_1), which was at par with water spray at flowering and pod development stages (F_2) (Table 1). The positive effect of potassium on haulm yield might be due to the pronounced role of potassium in photosynthesis, cell elongation and efficiently assimilate translocation that ultimately increased dry matter production as reflected in the form of higher haulm yield. Similar results were shown by Sakpal (2015) and Takankhar *et al*. (2017).

It can be concluded that from the above study application of RDF (20 : 50 kg N, P_2O_5 kg ha^{-1} + soil application of 40 kg K_2O or 30 kg K_2O ha^{-1} along with the foliar spray of 1% KH_2PO_4 or 1% KCl or 0.5% KNO_3 at flowering and pod development stages improved the growth and yield of blackgram.

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GROWTH AND YIELD OF SUPER EARLY VARIETIES OF REDGRAM [*Cajanus cajan* (L.) Millsp] UNDER DIFFERENT NUTRIENT LEVELS

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ABSTRACT

A field experiment was conducted at S.V. Agricultural College Farm, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India during *kharif*, 2021-22 to study the growth attributes and yield performance of super early varieties of redgram under graded levels of nutrients. The field experiment was conducted in a split pot design with three replications. The treatments consist of five varieties *viz.*, ICPL 11301, ICPL 20325, ICPL 20338, ICPL 11255 and ICPL 88039 main plots and three nutrient levels viz., 100, 125 and 150% RDF in sub plots Super early variety of redgram *i.e*., ICPL 88039 recorded significantly higher plant height, leaf area index and dry matter production, whereas, ICPL 11301 registered higher seed yield among the varieties tested. The highest nutrient dose of 150% RDF resulted in higher growth parameters and seed yield. However, the above parameters were at par with application of 125% RDF (25 kg N, 62.5 kg P_2O_5 and 50 kg k_2O).

KEYWORDS: Redgram, super early varieties, nutrient levels and seed yield

INTRODUCTION

Redgram is traditionally grown as an annual pulse crop in Asia, Africa, the Caribbean islands and Latin America. It is a good source of protein up to 22 percent, vitamins *viz.,* thiamine, riboflavin, niacin and choline and minerals *such as* iron, iodine, calcium, phosphorus, sulphur and potassium. In addition to its primary use as a dhal, its immature green seeds and pods are consumed as vegetable (Yadav *et al*., 2021). India ranks first in redgram production globally 3.88 million tonnes cultivated in an area of 4.82 million hectares with a productivity of 804 kg ha^{-1} (Anonymous, 2020).

Under a changing climate scenario, new short duration super early genotypes of redgram help in achieving a higher harvest index. With the introduction of super early redgram varieties maturing within 90-100 days opens the possibility to explore redgram cultivation during the off- season and non-traditional niches, aiming for an increase the national production pool of pulses. Super early varieties also demonstrated photo insensitivity, maturity synchrony, hardiness and adaptability to multiple cropping systems (Saxena *et al.,* 2019 and Naseeruddin *et al*., 2018). The low yield of redgram is not only due to its cultivation on marginal and sub marginal lands, but also due to poor crop management. For proper maintenance of the health of crops and to obtain a high yield, balanced fertilization is necessary throughout the crop period. Nitrogen, phosphorous and potassium are three major nutrients required for the crop production and should be used in proper proportion. Nitrogen and potassium when applied together have a synergistic effect on the crop. Only in the presence of an adequate amount of potassium the best response of nitrogen can be obtained (Sekhon *et al*., 2018). There is a need for identify suitable super early genotype of redgram and optimum dose of nutrients to increase the productivity and profitability of redgram.

MATERIAL AND METHODS

The present investigation was carried out at wetland farm, S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University which is geographically situated at 13.5°N latitude and 79.5°E longitude with an altitude of 182.9 m above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The present experiment was laid out in a split-plot design and replicated thrice. The treatments include five varieties *viz.,* ICPL 11301 (V1), ICPL 20325 (V2), ICPL 20338 (V3), ICPL 11255 (V4) and ICPL 88039 (V5) as main plots and three nutrient levels *viz.,* 100% RDF (N1), 125% RDF (N2) and 150% RDF (N3) as sub plots. The fertilizer was applied as basal using 100% RDF (20:50:40 kg N, P_2O_5 and K_2O ha^{-1}). The crop was sown at a spacing of 45 cm

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× 15 cm. The experimental field was sandy loam in texture which is low organic carbon (0.42%). The soil is neutral in reaction (pH 7.3), low in available N (162 kg ha^{-1}) and potassium (141 kg ha^{-1}) and medium in available phosphorus (36 kg ha^{-1}). A total rainfall of 1277.8 mm was received in 56 rainy days during the crop growing period. The nutrients were applied in the form of urea, single super phosphate and muriate of potash. All the other recommended practices were adopted as per the recommendations. The data collected on plant height, leaf area index, dry matter production and seed yield was analyzed statistically following the procedure for split plot given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Plant height

The highest plant height was noticed with ICPL 88039, which was significantly superior over other genotypes tried. ICPL 20325 and ICPL 11301 were the next best varieties in recording higher plant height with no significant disparity between them (Table 1). This was followed by ICPL 20338 which was however comparable with ICPL 11255, which recorded the lowest plant height. The increase in plant height among the varieties might be due to the variation in their genetic makeup, internodal length, nutrient absorption capacity and conversion of radiant energy in presence of chlorophyll. The above results are in conformity with the findings of Ranjani *et al*. (2018), Deepika (2020) and Shruthi (2020).

Among the different nutrient levels tried, higher plant height of redgram was noticed with application of 150% RDF, which was however comparable with application of 125% RDF and significantly superior over 100 % RDF, which recorded lower plant height. This might be due to the fact that higher level of nutrient application 150 % RDF resulted in more availability, better uptake and translocation of plant nutrients to plants, which helped in differentiation and expansion of component cells, cell division and cell multiplication thereby producing better plant height. Similar results were also reported by Dalai *et al*. (2019) and Parameshwarareddy *et al*. (2019).

Leaf area index

The highest leaf area index was produced by ICPL 88039, which was significantly higher than rest of the varieties tested. The next best variety in recording higher leaf area index was ICPL 20325, which in turn was comparable to ICPL 11301. The lowest leaf area index was produced by ICPL 11255 which was at par with ICPL 20338 (Table 1). Higher leaf area index was observed with ICPL 88039 due to better growth that was evident from the plant height, varietal differences in leaf area, number of green leaves and delayed senescence of leaves. These results are in agreement with the findings of Ranjani *et al*. (2018) and Shruthi (2020).

Leaf area index of redgram significantly varied due to nutrient levels. Crop fertilized with 150% RDF produced higher leaf area index, which was statistically at par with 125% RDF (Table 2). Significantly lower leaf area index was registered with 100% RDF. Higher leaf area index observed with application of 150% RDF might be due to increased nutrient availability in soil which made the plant to absorb more nutrients, which in turn increased the number of leaves, total leaf area $plant^{-1}$ and their effect on enlargement of cells of the leaf through their cell division and assimilation of photosynthates might have retained more leaf area. Similar findings were also reported by Nagamani (2015) and Parameswarareddy *et al*. (2019).

Drymatter production

The highest dry matter accrual was noticed with ICPL 88039 which was significantly superior to other varieties investigated (Table 1). This could be mainly due to increase in plant height, leaf area index and due to their genetic makeup. Increased assimilatory surface area per plant might have led to increased biomass production, which ultimately led to the accumulation of a large quantity of photo assimilates. This is in accordance with the results reported by Shruthi *et al*. (2020). The next best variety was ICPL 20325 which was however comparable with ICPL 11301. The variety ICPL 11255 (V4) produced the lower dry matter, but was however comparable with ICPL 20338.

With regard to nutrient levels, higher dry matter accumulation was registered with application of 150% RDF which was in parity with application of 125% RDF. The lowest dry matter production was with 100% RDF, which was significantly lower than the other two higher nutrient levels. Higher dry matter production obtained with 150% RDF might be due to increased availability of nutrients over the longer periods, better utilization of available growth resources *viz*., nutrient, moisture and solar radiation to a greater extent. It resulted in favourable

Table 1. Effect of graded levels of nutrients on plant height, leaf area index, dry matter production and seed yield of super early varieties of redgram

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Seed yield (kg ha^{-1})
Varieties (VI				
V_1 : ICPL 11301	105	2.10	4134	1279
V_2 : ICPL 20325	111	2.22	4490	1176
V_3 : ICPL 20338	77	1.52	3043	974
V_4 : ICPL 11255	75	1.40	2705	971
V5 : ICPL 88039	161	4.86	5332	1075
SEm±	3.2	0.046	123.1	30.1
CD (P = 0.05)	10	0.14	370	91
Nutrient levels (N)				
N_1 : 100 % RDF	99	1.95	3843	1007
N_2 : 125 % RDF	106	2.56	4498	1118
N_3 : 150 % RDF	110	2.62	4682	1160
SEm±	2.6	0.044	90.3	20.3
CD (P = 0.05)	6	0.12	270	60
Varieties (V) × Nutrient levels (N)				
N at V				
SEm±	5.4	0.076	193.4	47.7
CD (P = 0.05)	NS	NS	NS	NS
V at N				
SEm±	5.1	0.091	199.9	66.5
CD (P = 0.05)	NS	NS	NS	NS

effect on cell enlargement and production of larger leaves. This might have eventually reflected in higher photosynthetic efficiency and thereby accumulated higher quantity of dry matter. Enhanced dry matter production with adequate supply of nutrients as evidenced in this investigation, corroborates with the findings of Dalai *et al*. (2019) and Preetham *et al*. (2020).

Seed yield

Significantly higher seed yield was produced by the variety ICPL 11301 (Table 1). ICPL 20325 and ICPL 88039 were the next best varieties in recording higher seed yield, with significant disparity between them. Whereas, the lower seed yield was recorded with ICPL 11255, which was comparable with ICPL 20338. Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink. ICPL 11301 was found to be the best redgram variety with a seed yield of 1279 kg ha^{-1} due to efficient translocation of photosynthates from source to sink. However, ICPL 88039 recorded higher growth parameters during crop growth period but produced lower yield than ICPL 11301 due to poor translocation of photosynthates from vegetative parts to pods during pod development stage and maturity. Similar results of higher seed yield with different genotypes were reported by Srivastava *et al*. (2012) and Ranjani *et al*. (2018).

As regards the nutrient levels, the seed yield increased progressively from 100% RDF to 150% RDF. The highest seed yield was recorded with higher nutrient level of 150% RDF, which was at par with 125% RDF. The lowest seed yield was recorded with the lowest nutrient level of 100% RDF, which was significantly lesser than rest of the nutrient levels tried.

On the basis of above investigation, it can be inferred that ICPL 88039 was superior with respect to growth attributes and ICPL 11301 registered significantly higher seed yield compared other varieties tried. With respect to nutrient doses, application of 150% RDF resulted in higher growth attributes and seed yield which was however comparable with 125% RDF. It could be inferred that super early redgram variety, ICPL 11301 in combination with application of 125% RDF (25 kg N, 62.5 kg P_2O_5 and 60 kg K_2O) is the best option for obtaining higher growth parameters and seed yield on sandy loam soils of Sourhern Agro-Climatic Zone of Andhra Pradesh.

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