ISSN 2395-5945

THE JOURNAL OF RESEARCH PJTSAU

The J. Res. PJTSAU Vol. XLIX No.1 & 2 pp 1-78, Jan. - June, 2021

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The Journal of Research, PJTSAU

(Published quarterly in March, June, September and December)

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Research Article
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PHENOTYPIC SCREENING AND SINGLE MARKER ANALYSIS FOR BROWN PLANTHOPPER RESISTANCE IN RICE (*Oryza sativa* L.)

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Date of Receipt : 28-04-2021 Date of Acceptance : 06-05-2021

ABSTRACT

Brown planthopper (BPH), *Nilaparvata lugens* (Stål) is a destructive pest that poses a threat to the food security of rice producing countries. In order to breed rice varieties with resistance to the brown planthopper, it is necessary to identify highly resistant germplasm sources. Seventy-three genotypes were evaluated using standard seed box screening technique over a period of two seasons that have shown varied levels of response reactions to the planthopper. Simultaneously, fifty-three microsatellite markers linked to BPH resistance were employed to find their association with BPH resistance. This association was estimated using regression based Single Marker Analysis (SMA) in Microsoft Excel. The significant marker trait associations (MTAs) were indicated by a P-value (< 0.05) along with corresponding R^2 for each marker explaining the total phenotypic variation for BPH resistance accounted by markers. Statistically significant marker-trait associations were observed for five of the 39 polymorphic markers *viz,* RM335, RM510, RM589, RM8213 and RM494 indicating the possibility of significant putative genetic loci associated with BPH resistance on chromosomes 4, 6 and 10. The percentage of the total phenotypic variation as explained by the significant markers ranged from 1.0% to 24.4% suggesting the reliability of these genetic markers for further improvement of breeding for BPH resistance. Since these markers are linked with *Bph3*, *Bph17(t)*, *QBph6* and *QBph10* genes/QTLs respectively, the presence of these genes in the resistant germplasm lines found in the study could be exploited through marker-assisted breeding programs for the development of BPH resistant cultivars.

Brown planthopper, BPH, *Nilaparvata lugens* (Stål), (Hemiptera: Delphacidae) is considered to be the most devastating biological constraint that impedes rice production across many countries in Asia (Park *et al.,* 2008). It causes direct damage to the plants by sucking the phloem sap resulting in the drying of plants inciting hopperburn symptoms. The most common approach for controlling the pest is through the application of insecticides. The chemical means of control is not only costly but is also environmentally hazardous and leads to the development of insecticide resistance in BPH (Cheng and Zhu, 2006; Jhansi Lakshmi *et al*., 2010). In order to establish a sustainable pest management strategy, the right combination of breeding and management strategies must be found to reduce BPH's ecological fitness while keeping the pest below economic threshold levels (Bosque-Perez and Buddenhagen, 1992).

Host plant resistance has been considered as one of the most effective ways of controlling the brown planthopper which can be deployed into resistant rice cultivars using molecular markers (Khush, 2001). Molecular markers, unlike morphological traits, can show genotypic differences at the DNA level, making them more straightforward, accurate, and efficient for germplasm characterization and selection. Of all the available molecular markers, microsatellites (Wu and Tanskley, 1993; Yang *et al.,* 1994) are most widely used due to their co-dominant nature, high allelic diversity, automated and easily assayed by polymerase chain reaction. These microsatellite markers have been efficiently utilized for genome mapping, marker aided breeding and for deriving marker-trait associations (McCouch *et al.,* 2002; Yu *et al.,* 2003; Garris *et al.,* 2005).

Establishing marker-trait associations (MTAs) using phenotypic and marker data is highly useful in investigating the genetic nature of a trait that can aid in identification of the number and nature of genes/QTLs. Several markers reportedly linked to resistance against BPH biotype 4 (Jairin *et al*., 2007; Liu *et al*., 2015; Sun *et al*., 2005; Ren *et al*., 2016; Naik *et al*., 2018) have been utilized for establishing the association of

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markers with resistance using Single Marker Analysis (Meshram *et al.,* 2018). This analysis is a widely applied method that primarily detects the association between marker genotype and trait value and also gives an idea about its closeness to the QTL. Thus, in the present study, marker analysis was done with the reported BPH resistance linked markers to identify their linkage to the trait using single marker analysis.

MATERIAL AND METHODS

Plant Material : Seventy-three genotypes of rice including BPH gene differentials, resistant MAGIC lines, popular varieties, landraces and wild species were used in the study (Table 1). The gene differentials and wild species of rice were obtained from ICAR- Indian Institute of Rice Research, Rajendranagar, Hyderabad, while, the MAGIC lines, varieties and landraces were procured from the Institute of Biotechnology, PJTSAU, Hyderabad. The lines TN1 and PTB33 were used as susceptible and resistant checks respectively.

Screening for BPH Resistance : The material was evaluated following the Standard Seed box Screening Technique (SSST) for resistance reaction to BPH at ICAR-Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad for two seasons i.e., during the wet seasons of 2018 and 2019.

Mass rearing of BPH: Initially, BPH adults of the most prevalent biotype (biotype 4) were collected from the rice fields of ICAR-IIRR. Pure culture was maintained in the glasshouse at a temperature of 25± 5°C with a relative humidity of 60±5% on 60 day old potted plants of susceptible variety TN1. Mass rearing was done in cages. Adult females were released on pre-cleaned potted plants placed in oviposition cages and after four days of egg laying, the gravid females were removed and released on fresh TN1 plants for further egg laying in separate cages. Fresh plants were provided for the hatched nymphs. The hatched nymphs were utilized for experiments as and when they attained the desired age. A continuous pure culture of BPH was maintained during the period of study.

Mass screening: The seeds of the germplasm lines were pre-soaked and sown in rows in 60×45×10 cm seed boxes along with resistant (PTB33) and susceptible (TN1) checks with 20 seedlings per row. Twelve days old seedlings were infested with first instar nymphs of BPH at the rate of 6-8 per seedling. When 90% of the plants in the susceptible check TN1 died, the germplasm lines were scored according to the Standard Evaluation System developed by the International Rice Research Institute (IRRI, 2013) as presented in Table 2. After scoring individual seedlings of an entry, the average score for all the seedlings of that entry was calculated and used as an indicator of resistance reaction for that particular entry.

Table 1. List of 73 rice germplasm lines used in the present study

Sources	Germplasm lines
Gene Differentials	Mudgo, IR 64, ASD 7, Milyang 63, Rathuheenati, Babawee, ARC 10550, Swarnalatha, T12, Chinsaba, Pokkali, IR 65482-7-216, IR 71033-121-15, MUT NS1, OM 4498, RP 2068-18-3-5, MO1, MTU 1010, RP BIO 4918-230S, IR 26, IR 40, IR 66, IR72, Utrirajappan, Ndiang Marie, Sinasivappu, Balamwee, IR 62, Rathuheenati accession, IR 65482-136-2-2
MAGIC lines	M4, M201, M229, M284, M286, M312, M344, M359, IM6, M61, M80, M88, M123, M179, M182, M187, M276, M278, M293, M362, M289, M1, M131, M189, M190, M227, M240
Varieties and germplasm lines	BPT5204, RNR15048, KNM118, IET23993, BM71, 10-3, RPV1160, RPV1355, RPV1189
Wild species	CG211, CG171, PH190, CG180, CG156
Checks	PTB33, TN1

Table 2. Criteria for BPH damage score in greenhouse screening (IRRI, 2013)

Resistance score	Plant state	Rating
0	No damage	Highly Resistant
1	Very Slight damage	
3	Lower leaf wilted with two green upper leaves	Resistant
5	Two lower leaves wilted with one green upper leaf	Moderately resistant
7	All three leaves wilted but stem still green	Moderately susceptible
9	All plants dead	Susceptible

Genotyping of germplasm lines using BPH specific Gene Markers : Fifty-three microsatellite markers reported to be linked with BPH resistance genes (*Bph3, bph4, Bph17(t), Bph32, Bph33(t), Bph13(t), Bph18, bph7, Bph20(t), Bph29*) and QTLs (*QBph3, QBph3.1, Qbph4, Qbph6, Qbph10*) corresponding to biotype 4 were used for genotyping of the 73 germplasm lines (Table 3). Total genomic DNA was extracted from

Table 3. List of BPH gene specific markers used in the study

Gene	Linked Marker	References
Bph3	RM584, RM225, RM508, RM307	Jairin *et al.* (2007)
Bph3	RH784, RH078, RHD9, WH2, RHC10, W1	Liu *et al.* (2015)
bph4	RM217	Kawaguchi *et al.* (2001)
Bph17(t)	RM518, RM206, RM8213, MS10	Sun *et al.* (2005)
Bph32	RM8072, RM6775	Ren *et al.* (2016)
Bph33(t)	RM488, RM212, RM11522	Naik *et al.* (2018)
Bph13(t)	RM250, RM240	Liu *et al.* (2001)
Bph18	RM273, RM6506, RM3331	Jena *et al.* (2006)
bph7	RM3448	Kabir and Khush (1988); Qiu *et al.* (2014)
QBph3	RM313, RM7, RM2453	Sun *et al.* (2005)
Qbph3.1	RM231	Shabanimofrad *et al.* (2016)
Qbph4	RM551	Hu *et al.* (2015)
Qbph6	RM510, RM6818, RM8215, RM587, RM314	Sun *et al.* (2007)
Qbph10	RM484, RM496, RM216, RM333, RM228, RM406, RM494	Sun *et al.* (2005), Shabanimofrad *et al.* (2016)
Bph3, Bph32	RM588, RM589	Jairin *et al.* (2007)
Bph3, Bph17(t)	RM190, RM5953	Jairin *et al.* (2007)
Bph3, Qbph6	RM8101, RM469	Jairin *et al.* (2007)
Bph3, bph4, Qbph4, Bph17(t)	RM401	Jairin *et al.* (2007), Sun *et al.* (2005)
Bph3, bph4, Bph32	RM19291	Jairin *et al.* (2007)
Qbph4, Bph17(t)	RM335	Sun *et al.* (2005)
Bph20 (t), Bph29	RM435	Rahman *et al.* (2009), Wang *et al.* (2015)

young and succulent leaves of the genotypes using the CTAB method suggested by Murray and Thompson (1980). The quantification of DNA was carried out on 0.8 per cent agarose gel with diluted uncut ladder DNA as standard. The PCR reactions were performed in 10 μl reaction volumes using the BPH linked markers. The reaction mixture contained 2 μl of template DNA, each 0.5 μl of forward and reverse primers, 4 μl TAKARA master mix and 3 μl of double distilled water. The amplification profile was maintained at 94°C for 5 min followed by 35 cycles of 94°C for 30 sec, 55°C for 1 min and 72°C for 1 min with a final extension of 7 min at 72°C. The amplified PCR products were electrophoretically resolved on a 3% agarose gel using 1×TAE buffer. DNA banding patterns were visualized using BIO-RAD Imaging gel documentation system. The list of the markers used is presented here under (Table 3).

Scoring and Data Analysis : All the germplasm lines were scored for the presence and absence of the SSR bands. Clearly resolved unambiguous bands were scored visually for their presence or absence with each BPH specific marker. The scores were obtained in the form of matrix with "1" and "0", which indicate the presence and absence of bands in each germplasm line respectively.

Identification of DNA markers associated with BPH resistance in rice germplasm : The marker-trait associations were estimated by Single Marker Analysis (SMA) with regression method using single factor standard analysis of variance (ANOVA). The marker trait associations with P-value < 0.05 were identified as significant. The proportion of phenotypic variance of the trait that is accounted by markers was estimated in per cent R^2 value.

RESULTS AND DISCUSSION

Phenotypic screening for BPH resistance : In the present study, an attempt was made to assess the level of BPH resistance of 73 genotypes of rice using Standard Seed box Screening Technique (SSST). The results of phenotypic response of genotypes to brown planthopper screening indicated varied levels of resistance reactions (Table 4). Out of the 73 lines, 16 genotypes comprising of three gene differentials (RP 2068-18-3-5, RP BIO 4918-230S, RathuHeenati), seven MAGIC lines (M4, M344, M284, M359, M312, M286, IM6), three wild species (CG180, CG156, PH190) and two germplasm lines (BM71, 10-3) along with resistant check PTB33 were found to be resistant with a score ranging from 1.3 to 3.0. Several workers have reported PTB33 as resistant to BPH which is being currently used as a resistant check in the screening studies (Nagendra Reddy *et al*., 2016; Ramulamma *et al.,* 2015; Udayasree *et al.,* 2018; Thamarai *et al.,* 2017). Similarly, BM71 (Bhanu *et al.,* 2014), RP 2068-18-3-5 and RP BIO 4918-230S (Akanksha *et al.,* 2019; Sunil *et al*., 2018) were reported to be resistant which was in accordance with the results obtained in the present study.

Table 4. Grouping of genotypes based on reaction to BPH damage

DAMAGE SCORE	REACTION	GENOTYPES
1.0-3.0	Resistant	PTB33, Rathu Heenati, RP 2068-18-3-5, RP BIO 4918-230S, M4, M284, M286, M312, M344, M359, PH190, CG180, CG156, BM71, IM6, 10-3
3.1-5.0	Moderately resistant	M229, M201, Mudgo, T12, SinnaSivappu, M61, M80, RPV1355, RPV1189, Rathuheenati accession, IET23993, CG171
5.1-7.0	Moderately susceptible	IR 64, OM 4498, IR 40, M88, M278, M289, M1
7.1-8.9	Susceptible	M227, M240, M362, Swarnalatha, IR 65482-7-216, MO1, M189, IR 62, Ndiang Marie, M179, M182, RPV1160, Babawee, CG211, M123, IR 66, IR 26, IR 65482-136-2-2,ASD7
9.0	Highly susceptible	Milyang 63, Chinsaba, ARC 10550, Pokkali, IR 71033-121-15, MUT NS1, MTU 1010, IR 72, Utrirajappan, Balamwee, M187, M276, M293, M131, M190, KNM118, BPT5204, RNR15048, TN1

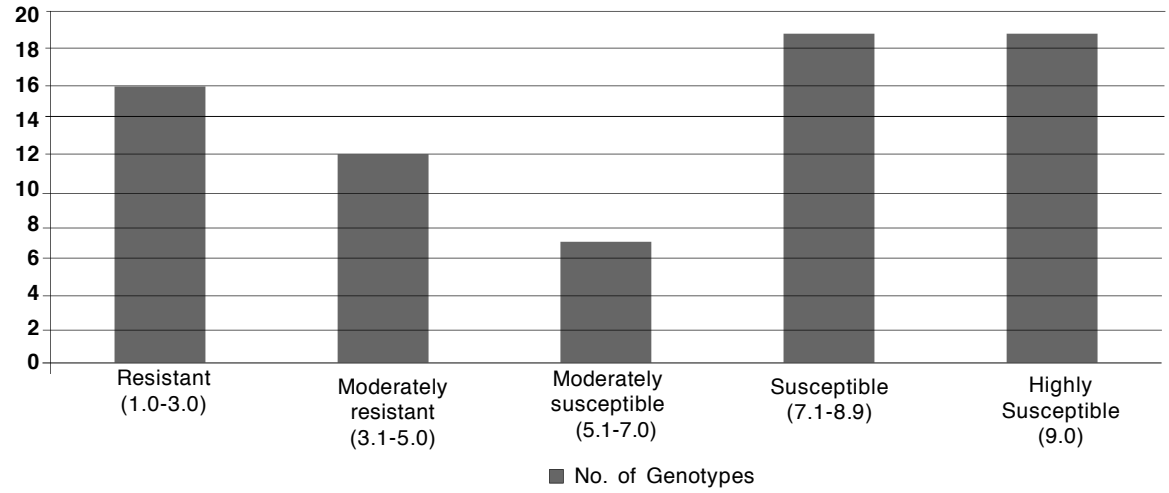

Fig 1. Histogram depicting the number of genotypes in each class of BPH reaction

Twelve genotypes (M229 (3.1), M201 (3.2), Mudgo (3.3), Rathuheenati accession (3.7), CG171 (3.8), IET23993 (4.3), RPV1355 (4.5), RPV1189 (4.6), T12 (4.7), SinnaSivappu (5.0), M61 (5.0), M80 (5.0)) were moderately resistant to BPH with a score between 3 and 5. Similarly, seven genotypes (M278 (5.5), M289 (5.7), IR 64 (6.0), M88 (6.3), M1 (6.5), OM 4498 (6.9), IR 40 (6.9) were moderately susceptible with a score of 5.1-7.0 (Table 4, Fig. 1), while 19 genotypes were recorded to be susceptible (damage score of 7.1-8.9). The remaining 19 genotypes were noted to be highly susceptible with a score of 9.0. Similar studies were taken up by Gangaram *et al.* (2019) who evaluated 74 rice genotypes of Sikkim and Tripura for resistance to Brown planthopper in glasshouse conditions along with resistant (PTB-33) and susceptible (TN1) checks.

Single marker analysis and BPH resistance

Marker-trait associations provide information about the presence of trait-linked QTLs/genes in germplasm lines with different genetic backgrounds. A strong association is favoured in marker-assisted breeding programmes to meritoriously exploit the specific marker for trait improvement (Breseghello and Sorrells, 2006). Accordingly in the present study, a total of 53 markers specific to BPH resistant loci (Fig. 2) were used for genotyping of the germplasm lines which detected 103 alleles. Thirty-nine markers out of 53 (73%) were found to be polymorphic in the lines with a mean of 2.73 alleles per locus. For testing of the genetic associations among 39 polymorphic markers and BPH resistance, single-factor ANOVA based single marker analysis was accomplished. Statistically significant genetic associations were observed among five polymorphic markers (RM 335, RM510, RM589, RM8213 and RM494) and BPH resistance with P value <0.05 (Table 5). Highest significant association for BPH resistance was observed for RM335 linked to *Bph17(t)* on chromosome 4 with a P value of 0.013 and was followed by RM510 linked to *Qbph6* on chromosome 6 (P=0.014), RM589 of *Bph3* gene on chromosome 6 (P=0.019), RM8213 of *Bph17(t)* on chromosome 4 (P=0.027) and RM494 of *Qbph10* on chromosome 10 (P=0.020). Remaining markers were non-significant with P values ranging from 0.06 (RM240) to 0.91 (RM8215). Similar studies of single marker analysis for BPH resistance were carried out by Meshram *et al.* (2018) while working with 24 elite rice genotypes where the marker RM6869 was found to be associated with BPH resistance.

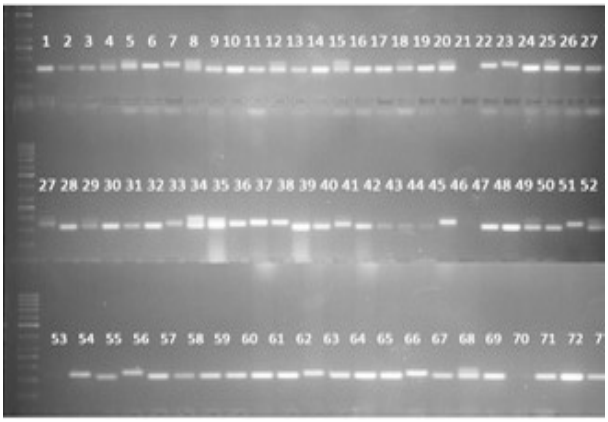

Fig 2. Polymorphism detected by MS10 marker specific to *Bph3*

Table 5. Marker R^2 and P values of molecular markers used for finding MTA with BPH resistance

S.No	Trait	Marker	Chromosome	P Value	Marker R^2
1	BPH	RM212	1	0.166596	0.02058
2	BPH	RM488	1	0.678552	0.00163
3	BPH	RM250	2	0.104433	0.03408
4	BPH	RM240	2	0.066169	0.07448
5	BPH	RM231	3	0.10077	0.12612
6	BPH	RM7	3	0.420154	0.01281
7	BPH	RM401	4	0.452838	0.05909
8	BPH	RM335	4	0.01300	0.24407
9	BPH	RM518	4	0.713921	0.0406
10	BPH	RM8213	4	0.027279	0.20045
11	BPH	RM206	4	0.095613	0.02357
12	BPH	RM307	4	0.095784	0.04093
13	BPH	MS10	4	0.126742	0.12369
14	BPH	RH078	4	0.852715	0.01318
15	BPH	WH2	4	0.125289	0
16	BPH	RM19291	6	0.27152	0.05884
17	BPH	RM190	6	0.537728	0.00135
18	BPH	RM589	6	0.019872	0.1748
19	BPH	RM588	6	0.407546	0.02718
20	BPH	RM435	6	0.177837	0
21	BPH	RM508	6	0.340923	0.02093
22	BPH	RM225	6	0.833526	0.0295
23	BPH	RM469	6	0.820052	0.02541
24	BPH	RM584	6	0.571697	0.03426
25	BPH	RM314	6	0.649372	0
26	BPH	RM6775	6	0.787715	0.00813
27	BPH	RM217	6	0.836174	0.01425
28	BPH	RM510	6	0.01401	0.01905
29	BPH	RM8215	6	0.912976	0
30	BPH	RM587	6	0.767315	0.00408
31	BPH	RM228	6	0.324608	0.04381
32	BPH	RM508	6	0.590535	0.00565
33	BPH	RM216	10	0.560864	0.01987
34	BPH	RM496	10	0.159373	0.003
35	BPH	RM484	10	0.149467	0.00189
36	BPH	RM494	10	0.020474	0.01002
37	BPH	RM333	10	0.239739	0.02336
38	BPH	RM3448	12	0.844387	0.02665
39	BPH	RM3331	12	0.105472	0.06469

Table 6 . Association between SSR markers and BPH resistance *P*<0.05

Marker	Chromosome	P value	Marker R^2
RM8213	4	0.027279	0.20045
RM335	4	0.01300	0.24407
RM589	6	0.019872	0.1748
RM510	6	0.01401	0.01905
RM494	10	0.020474	0.01002

As estimation of proportion of the phenotypic variance (R^2) as explained by molecular markers plays an important role in quantitative traits and in marker-assisted selection (Bearzoti and Vencovsky, 1998). Among the five markers found to be associated with BPH resistance, RM335 was found to be having the highest contribution to the phenotypic variance R^2 (0.24), followed by RM8213 (0.20), RM589 (0.17), RM510 (0.01) and RM494 (0.01). These five significant marker-trait associations accounted up to 24% of the total observed phenotypic variance (R^2). The higher phenotypic variance values indicated the influence of markers over a considerable amount of genetic variation in BPH reaction and also could be reliable genetic markers for further improvement of breeding for BPH resistance.

On the whole, the present investigation helped in the identification of 18 BPH resistant donors which could be useful in breeding BPH resistant rice varieties. Further investigations on presence of other mechanisms of resistance need to be attempted to confirm the best germplasm lines as potential donors for BPH resistance. With regard to the markers associated with resistance, RM335 and RM8213 (chromosome 4) associated with *Bph17(t)* as stated by Sun *et al.* (2005), RM589 for *Bph3* (Jairin *et al.,* 2007), and RM510 for *Qbph6* (Sun *et al*., 2007) found on chromosome 6 and marker RM494 on chromosome 10 for *Qbph10* (Sun *et al.,* 2005) were identified as significant in the study (Table 6). Based on the SMA results, it can be inferred that the four genes/QTLs (*Bph3*, *Bph17(t), Qbph6 and Qbph10*) might have been linked with resistance in the germplasm.

CONCLUSION

Single marker analysis is relatively a simple method of QTL analysis that can be conducted as a first step to detect the associations between molecular markers and traits of interest. In the present study, microsatellite markers specific to BPH resistance were subjected to marker-trait analysis utilizing the phenotypic response of the germplasm lines to BPH. Of the 39 polymorphic markers, RM335 and RM8213 found on chromosome 4, RM589 and RM510 on chromosome 6 and marker RM494 on chromosome 10 were identified as possible genetic loci conferring BPH resistance. The results indicate the presence of four genes/QTLs (*Bph3*, *Bph17(t)*, *Qbph6 and Qbph10*) in the germplasm panel that could be the force behind resistance to BPH. Overall, significant MTAs indicated potential application of high resistance linked alleles for the development of BPH resistant cultivars. These significant markers could be validated using diverse and large germplasm sets for future use in marker-assisted resistance breeding.

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Research Article
The J. Res. PJTSAU 49 (1&2) 10-16, 2021

CORRELATION STUDIES BETWEEN YIELD AND YIELD ATTRIBUTES OF ELITE RICE GENOTYPES TRANSPLANTED UNDER DIFFERENT GROWING ENVIRONMENTS

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Date of Receipt : 10-02-2021 Date of Acceptance : 15-03-2021

ABSTRACT

The present investigation was carried out at Indian Institute of Rice Research (IIRR) Rajendranagar, Hyderabad to study the direction and degree of correlations between the different parameters of yield attributes and economic yield of 6 elite rice genotypes transplanted under 12 sowing dates that contribute to different growing environment during 2018-19. Character association studies revealed that the parameter grain yield (kg ha^{-1}) showed significant positive association with panicle length, panicle weight, number of filled grains per m^{-2}, grain number per panicle, test weight and spikelet fertility. Therefore, advancement in grain yield is possible by giving emphasis on these characters in selection scheme. Further, the yield attributes were correlated with each other which stated that panicle length was positively influenced by panicle weight and grain number per panicle. Similarly, the panicle weight was positively dependent on filled grain number, grain number per panicle and 1000 grain weight (test weight). The filled grain number was in turn positively impacted by grain number per panicle and 1000 grain weight (test weight). Likewise, the spikelet fertility was positively determined by panicle weight, and test weight. Among the genotypes, the strength and direction of correlation between yield and yield attributes was high and more conspicuous in JGL 3844. Therefore the present investigation clearly inferred that the quantitative traits of most of the yield attributes were contributing to economic yield in different rice genotypes and were highly interdependent.

Rice (*Oryza sativa* L.) belongs to the tribe *Oryzae* which is one of the largest and most important tribes in the grass *Poaceae* family. Rice grain consumed by nearly half the world's population is grown in 114 countries around the world (Patel *et al.,* 2019). Among the rice growing countries, India holds the largest area of 44.5 million ha, with a production of 115.60 Mt and a productivity of 2800 kg ha^{-1} (Directorate of economics and statistics, 2019). In Telangana, rice is grown in an area of 2.09 million ha with a production of 6.62 Mt, and productivity of 3295 kg ha^{-1} (CMIE, 2019).

The increasing frequency of temperature extremes, onset of droughts, storms and floods, a rapidly growing population and urbanization are major constraints against ensuring food security (Zeng *et al.,* 2017). Therefore, it is essential to develop high-yielding, climate-resilient and high-quality rice cultivars (Venu *et al.,* 2011). To safeguard and sustain the food security in India, it is important to increase the productivity of rice under limited resources. It is now realized that sustaining as well as increasing productivity may be essential. The knowledge of factors responsible for high yields has been rendered difficult as yield is a complex character (Singh *et al.,* 2010).

Yield potential in rice is governed by various factors like weather conditions, the cultivar type, planting time, location, agronomic practices, etc. Planting time and selection of variety may play the deciding role in performance of rice, hence choice of correct variety and selection of right time of transplanting is of utmost importance under the particular agro climatic condition (Anil *et al.,* 2009). The environmental effect can be best studied by imposing staggered sowings. The yield components and yield associated parameters are decided during crop growth period. Growth cycle of rice plant can be divided into three stages *viz.,* vegetative, reproductive and spikelet filling or ripening. Yield potential of rice is defined during these growth stages and includes, number of panicles per unit area, number of spikelets per panicle, panicle length, weight of spikelet and spikelet sterility (Fageria, 2007). In addition, shoot dry weight, grain harvest index, and nitrogen (N) harvest index are also positively associated with grain yield. The estimation of these character association identifies the relative importance of independent

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character (s) that may be useful as indicator(s) for one or more characters (Ashok *et al.,* 2016). Correlation studies provide a better understanding of the association of different characters with grain yield (Dixet and Dubey, 1984). The study of associations among various traits is useful to breeders in selecting genotypes possessing groups of desired traits. Hence, the present study was takenup to find out correlation between yield and yield components of rice for increased grain yield in rice.

MATERIAL AND METHODS

The present study was carried out at IIRR (Indian Institute of Rice Research), Rajendranagar, Hyderabad during June 2018 to June 2019 on medium fertile black sandy loam soils with pH 7.6. The experiment was laid out in split plot design with three replications, considering six cultivars as main plot and twelve dates of sowing as sub plot treatment. The twelve different dates of sowing were considered from 20th June 2018 to 01st February 2019 with an interval of 20 days between each sowing. The six cultivars in the study were RNR 15048, WGL 24071, IR-64, JGL 3844, JGL 3855 and JGL 11470. The plots were prepared for transplantation by puddling upto a depth of 5 cm. The nursery beds for respective sowing dates were laid 1 month in advance to obtain 30 days old saplings for timely transplantation. Around 2-3 plants per hill were transplanted with a spacing of 20x15 cm. Recommended doses of fertilizers were applied and plant protection measures were taken following standard package of practices (Vyavasaya panchangam, 2020).

Various yield contributing parameters (yield attributes) such as panicle length, panicle weight, grain number per panicle, filled grain number m^{-2}, unfilled grain number m^{-2}, test weight, spikelet fertility and yield were

Table 1. Pearson correlation coefficients between yield and yield attributing characters across different dates of sowing in rice.

Note:

§ PL-Panicle length

Parameters	RNR 15048	WGL 24071	IR-64	JGL 3844	JGL 3855	JGL 11470
SF-PL	0.123	0.511	0.555	0.708**	0.485	0.485
SF-PW	0.660*	0.813**	0.382	0.832**	0.753**	0.838**
SF-FGNO. m^{-2}	0.556	0.715**	0.336	0.694*	0.557	0.692*
SF-UNFGNO. m^{-2}	-0.930**	-0.978**	-0.858**	-0.987**	-0.926**	-0.988**
SF-GNO. P^{-1}	0.051	-0.363	-0.083	0.171	0.417	0.019
SF-1000GW	0.729**	0.679*	0.516	-0.015	0.059	0.983**
PL-PW	0.734**	0.582*	0.754**	0.756**	0.758**	0.943**
PL-FGNO. m^{-2}	0.556	0.315	0.533	0.575*	0.491	0.724**
PL-UNFGNO. m^{-2}	-0.053	-0.541	-0.388	-0.490	-0.391	-0.656*
PL- GNo. P^{-1}	0.807**	0.041	0.476	0.629*	0.736**	0.610*
PL-1000GW	0.311	0.126	0.401	0.499	0.050	0.244
PW- FGNO. m^{-2}	0.896**	0.867**	0.793**	0.820**	0.792**	0.821**
PW- UNFGNO. m^{-2}	-0.532	-0.728**	-0.041	-0.792**	-0.579*	-0.772**
PW- GNo. P^{-1}	0.714**	0.226	0.759**	0.542	0.889**	0.608*
PW-1000GW	0.762**	0.631*	0.511	0.854**	0.446	0.316
FGNO.m^{-2} - UNFGNO. m^{-2}	-0.333	-0.603*	0.169	-0.593*	-0.226	-0.581*
FGNO.m^{-2} - GNo. P^{-1}	0.724**	0.217	0.830**	0.549	0.778**	0.642*

Parameters	RNR 15048	WGL 24071	IR-64	JGL 3844	JGL 3855	JGL 11470
FGNO. m^{-2}- 1000GW	0.662*	0.536	0.671*	0.709**	0.401	0.225
UNFGNO.m^{-2} - GNo. P^{-1}	0.091	0.462	0.482	0.063	-0.191	-0.053
UNFGNO. m^{-2}- 1000GW	-0.576*	-0.557	-0.200	-0.963**	0.092	0.087
GNo. P^{-1}-1000GW	0.367	-0.111	0.523	0.086	0.570	0.514
GRAIN Y – PL	0.560	0.722**	0.666*	0.485	0.626*	0.833**
GRAIN Y–PW	0.797**	0.803**	0.623*	0.865**	0.857**	0.838**
GRAIN Y -FGNO. m^{-2}	0.808**	0.678*	0.661*	0.901**	0.772**	0.629*
GRAIN Y -UNFGNO. m^{-2}	-0.261	-0.567	-0.370	-0.597*	-0.265	0.578*
GRAIN Y - GNo. P^{-1}	0.713**	0.165	0.497	0.595*	0.895**	0.480
GRAIN Y - 1000GW	0.680*	0.474	0.748**	0.713**	0.618*	0.415
GRAIN Y – SF	0.493	0.648*	0.682**	0.635*	0.482	0.689*

- PW-Panicle Weight
- FGNO. m^{-2}-Filled Grain Number m^{-2}
- UNFGNO. m^{-2}-UnFilled Grain Number m^{-2}
- G No. P^{-1}-Grain Number per Panicle
- 1000GW- Test Weight
- GRAIN Y- Grain Yield
- SF - Spikelet Fertility

**- Highly Significant, *-Significant (*, **—Significant at 5% and 1% respectively)

recorded in the crop across twelve different dates of sowing. The data collected on yield attributes were then correlated with yield and their respective coefficient values (r) showing the strength of relationship (**-highly significant and *-significant) were determined following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The correlation coefficient values (r) obtained between yield attributes and yield for each genotype across different sowing dates have been presented in table 1.1.

Spikelet Fertility (SF %)

Spikelet fertility was determined to estimate the percentage filled grains obtained from each panicle. By the correlation analysis it was revealed that the SF has a positive and significant relation with all the yield and yield attributing characters, except for unfilled grain number which recorded a negative correlation. Based on the correlation results obtained, the SF does not possess any significant effect on panicle length.

SF has shown effect on panicle weight as it recorded a positive significant correlation for all the cultivars except IR-64. This indicates that SF directly determines the panicle weight, as fertile spikelets are responsible for pollination and fertilization of ovules, which later accumulated assimilates to form grain. Further, the correlations has shown that SF is responsible for the number of filled grains, as a positive and significant effect was recorded for cv. WGL 24071, JGL 3844 and JGL 11470 with maximum value (0.715**) in WGL 24071. The fertility rate decides the number of spikelets to form filled grains. The number of potential grains per panicle is set by the time of panicle differentiates at base of stem (Moldenhauer *et al.,* 1914) and hence no correlation was observed for SF with grain number per panicle.

Test weight in rice is a genotype specific character, as it is determined by the length, breadth and density of grain, which inturn are controlled by cultivar specific genes. Ramanjaneyulu *et al.,* (2014) stated that the yield attribute 1000-grain weight exhibited the maximum contribution to total genetic divergence (57.78%), followed by grain yield (15.56%), number of grains/spikelet (11.11%) and spikelet length (4.44%). SF might partially regulate the test weight (1000 GW) as it was significantly and positively correlated in cv. RNR 15048, WGL 24071 and JGL 11470.

Correlation analysis by Chen *et al.,* (2017) showed that spikelet fertility rates were positively and significantly related with daily mean temperature and daily maximum temperature (R^2 = 0.6604 and 0.7017, P < 0.01), suggesting that high temperature increases spikelet fertility. The sowing dates followed in the present study coincided with low temperatures in the months of October to January, which reflected on percentage of SF. Hence, a negative and highly significant correlation was recorded between unfilled grain number and spikelet fertility in all the cultivars. The strongest negative correlation was observed for cv. JGL 11470 (-0.988**). Similar results were observed by Zheng *et al.,* (2017) who stated that based on spikelet position, low temperatures significantly reduced spikelet fertility in the upper, middle, and lower parts of the panicle. Daba *et al.,* (2015) recorded strong negative correlations between yield and spikelet sterility (-0.815**) in a study with 224 germplasm at three dates of sowing.

Panicle Length (PL)

Panicle length is one aspect of panicle architecture, usually measured as a yield-related trait. Panicle length, together with spikelet number and density, seed setting rate and grain plumpness, determines the grain number per panicle and consequently increases the yield in rice (Liu *et al.,* 2016). All the cultivars recorded highly significant and positive correlation between panicle length (PL) and panicle weight (PW) with strongest association noted for cv. JGL 11470 (0.943**). However, the panicle length and weight are indirectly related to each other as, an increase in panicle length positively increases the filled grain number per panicle resulting in heavier panicle weights.

Ashura (1998) stated that number of filled grains per panicle was positively correlated with panicle length (r = 0.598) indicating that the plants with large panicles tend to have a high number of fertile grains. The correlation between PL and filled grain number per m^2 (FGNO. m^{-2}) was recorded only in the cv. JGL 3844 and JGL 11470 and the strength of association was highest in JGL 11470 (0.724**). Similar correlation results were obtained by Rahman *et al.* (2014) for number of filled grains per panicle and panicle length.

Under a high-yield environment without stress, increasing sink size or the number of spikelets per unit land area can be achieved either by increasing panicle number or panicle size (Takeda, 1985). The association between grain number $panicle^{-1}$ (GNO.P^{-1}) and PL was significant and positive for the cultivars with the strongest correlation observed for RNR 15048 (0.807**). This indicates that longer the panicle more the number of spikelets arranged per panicle which can thus increase the filled grain number resulting in higher yield. No significant correlation was observed between PL and unfilled grain number (UNFGNO. m^{-2}) for the cultivars except in JGL 11470 (-0.656*). This shows that the panicle length has no effect on deciding the unfilled grain number in panicle.

Panicle Weight (PW)

The association of PW with FGNo. m^{-2} was highly significant and positive for all the cultivars with highest coefficient value for cv. RNR 15048 (0.896**). Thus, it can be attributed that panicle weight and filled grain number were directly proportional to each other.

Similar, positive and significant relation was recorded between panicle weight and grain number $panicle^{-1}$ for the cultivars over different sowing dates and might be because the panicle weight and grain number $panicle^{-1}$ are linearly related. Further, the test weight, which is genotype specific, has also shown positive and significant correlation with panicle weight, with maximum correlation observed for JGL 3844 (0.854**). The potential grain weight is mostly dependent on genotype, but it may be limited to some extent by post-anthesis assimilate supply, Leaf Area Index (LAI) and Lead Area Duration (LAD), which in turn is governed by water availability. Therefore, test weight is determined by the grain size and the duration of grain fill, both of which are markedly affected by water stress (Kumar *et al.,* 2014). Similar results were noted by Ganghua *et al.,* (2014) where the panicle weight was positively related to spikelet number per panicle and grain weight for both years of study.

In contrast, PW and unfilled grain number m^{-2} recorded a significant and negative correlation with maximum association observed for JGL 3844 (-0.792**). This negative correlation is obvious, since the panicle weight decreases, as unfilled grain number increases.

Filled Grain Number (FGNO. m^{-2})

The reproductive stage determines the total and filled grains per panicle. Further, the potential number of grains and filled grains per panicle plays an important role in determining the final grain yield of rice plants through its effect on the sink size*, i.e.* test weight (Kishor *et al*., 2017). The coefficient values between filled grain number and grain number per panicle were positive and significant. Maximum association was recorded in cv. IR-64 (0.830**). Similar positive and significant correlation was recorded between filled grain number and test weight (1000 grain weight), with maximum coefficient value in cv. JGL 3844 (0.709**). Gravois (1992) reported that increasing grain weight is one means of increasing grain yields.

Given that the spikelet fertility was not determined by the number of grains per panicle, the unfilled grain number was also unaffected by it. Hence, no significant association between unfilled grain number and grain number per panicle was observed. The association of unfilled grain number with test weight was negative and significant in cv. RNR 15048 (-0.576*) and JGL 3844 (-0.963**). This implies that, although the number of unfilled grains was more causing less number of filled grains per panicle, the partitioning of assimilates was not to the fullest which resulted in decreased test weight.

As it is apparent that filled and unfilled grain number have contradictory effect on grain yield, a negative and significant correlation was observed between filled grain number and unfilled grain number, with maximum coefficient value in cv. WGL 24071 (-0.603*).

Grain Yield

Direct and indirect yield components compensate with each other, and an increase or decrease in one component does not necessarily result in an overall increase in grain yield. It is difficult to increase rice yield potential by improving a single yield trait (Qian *et al.,* 2016). The correlation studies of yield attributes with grain yield revealed that, grain yield was positively and significantly correlated with panicle length for three cultivars under study with highest association in JGL 11470 (0.833**). IRRI studies revealed that among all the measured yield-related traits, panicle size had the most consistent and closest positive correlation with grain yield (Rebecca *et al.,* 2004).

Heavy-panicle rice possess high-yielding potential and may provide an ideal way for development of new high-yielding varieties (Yuan, 2012). China initiated super rice breeding project in 1996 and has raised attainable rice yield record from 10.5 to 15 t ha^{-1} in succession with a large number of heavy-panicle varieties (Cheng *et al.,* 2007). In the present study, the grain yield recorded positive and significant relation with panicle weight for all the cultivars with maximum association in cv. JGL 3844 (0.865**). This indicates the importance of developing heavy panicle bearing cultivars to attain maximum yields.

Grain yield recorded a significant and positive correlation with filled grain number in all the cultivars, as they constitute the important component of grain yield. The cv. JGL 3844 (0.901**) was observed to have maximum correlation coefficient value between grain yield and filled grain number. These results were in line with Karki *et al.,* (2018) who observed a positive correlation between the grain yield and effective tillers per square meter (R^2 =0.254), grain yield and number of filled grains per panicle (R^2 =0.315).

Further, the correlation between grain yield and test weight was found to be significant and positive for all cultivars except WGL 24071. Maximum association was recorded by cv. IR-64 (0.748**). The association between grain yield and grain number per panicle was positive and significant in cv. RNR 15048, JGL 3844 and JGL 3855. Highest correlation coefficient value was recorded by cv. JGL 3855 (0.895**).

The character association studies by Ashok (2016) revealed that the number of productive tillers per plant (Bornare *et al.,* 2014), number of total grains per panicle (Panwar *et al.,* 2006) and test weight (Rashid *et al*., 2014) had significant positive association with grain yield at both phenotypic and genotypic levels. The grain yield has also shown positive correlation with spikelet fertility (%) as in JGL 11470 (0.689**). It can be stated that fertility of the spikelets increases the number of filled grains per panicle which increases the panicle weight that in turn reflects on grain yield.

In contrast, as anticipated the grain yield showed a significant and negative correlation with unfilled grain number.

CONCLUSION

A perusal of the results on character associations for grain yield and yield components revealed that the grain yield (per kg ha^{-1}) can be determined by performance of crop in terms of panicle length, panicle weight, number of filled grains per m^{-2}, grain number per panicle, test weight and spikelet fertility as they showed significant and positive association. Hence, it is logical to conclude that these parameters are major contributors towards grain yield. Further, the correlation studies showed the yield attributing characters to be inter dependent, with panicle length, panicle weight, number of filled grains per m^{-2}, 1000 grain weight and spikelet fertility sharing a positive association with each other to attain better yields. Comparison between the cultivars revealed cv. JGL 3844 to have the highest strength and direction of correlation for yield and yield attributes.

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Research Article
The J. Res. PJTSAU 49 (1&2) 17-24, 2021

ASPERGILLUS FLAVUS SOIL POPULATIONS IN MAJOR GROUNDNUT GROWING DISTRICTS OF TELANGANA STATE

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Date of Receipt : 05-01-2021 Date of Acceptance : 18-03-2021

ABSTRACT

Aflatoxin contamination, caused by *Aspergillus flavus* group of fungi, is a serious threat to groundnut crop profitability and human health. The objective of this study was to know the distribution of soil population density of *A. flavus* and its relation with soil chemical and physical properties. The soil samples collected from different groundnut growing locations of Telangana state during *rabi,* 2018-19 and *kharif,* 2019 were analysed for *A. flavus* population and for soil properties (pH, exchangeable calcium content and organic carbon). Soils of Mahabubnagar district had the highest *A. flavus* population of 7.8×10^3 cfu/g and 6.4×10^3 cfu/g of soil during *rabi,* 2018-19 and *kharif,* 2019 respectively whereas the lowest *A. flavus* populations were observed in soils of Warangal district with 1.5×10^3 cfu/g and Nagarkurnool district with 2.8×10^3 cfu/g during *rabi,* 2018-19 and *kharif,* 2019, respectively. A negative correlation was observed between soil calcium content and *A. flavus* population count. Overall, our study found varied levels of *A. flavus* populations in the groundnut cropping areas of Telangana state with highest *A. flavus* population at Mahabubnagar district during both seasons.

Groundnut (Peanut; *Arachis hypogaea* L.) is an important food legume and 4th most important oilseed crop of the world. Groundnut kernels are consumed directly as raw, roasted or boiled kernels and the oil extracted from the kernel is used as culinary oil. Groundnut is cultivated worldwide in tropical, subtropical and warm areas in an area of 29.59 mha with annual production of 48.75 mt (FAOSTAT, 2019). In India, the crop is grown to an extent of 4.8 mha with a production of 9.2 mt (INDIASTAT, 2019). In Telangana state, the crop is grown to an extent of 0.13 mha with a production of 0.30 mt and a productivity of 2364 kg ha^{-1} (Directorate of Economics and Statistics, 2019).

Aflatoxin contamination, caused by *Aspergillus flavus* group of fungi, is a serious threat to groundnut crop profitability and human health. Many strains of this fungus are capable of producing aflatoxins that render the seed unacceptable due to high toxicity for human or animal consumption (Negash, 2018). Aflatoxins are highly toxic substances associated with Reye's syndrome, Kwashiorkor and acute hepatitis (Wild and Turner, 2002). *A. flavus* is predominantly a soil inhabitant saprophyte that infects the groundnut kernels under favourable conditions and leads to pre-harvest aflatoxin contamination in kernels. Though it is a saprophyte, groundnut seed, seedlings and pods are subjected to the attack of this fungus. It also invades the pods during pod developmental stage and further reduces the seed quality and leads to pre-harvest aflatoxin content. Pre-disposing factors for aflatoxin contamination in groundnut include moisture stress during the last 3-4 weeks of crop growth coupled with high soil temperature, damage due to soil insects and nematode damages, natural cracking, and mechanical damage to the pods by harvest equipment (Pettit and Taber, 1968; Waliyar *et al.,* 2007). Ravi Teja *et al.* (2017) reported that aflatoxin in kernels collected from oil mills in Telangana state was highest in samples from Rangareddy with 1205.2 µg/kg followed by Karimnagar district with 365.5 µg/kg. There were very few studies in the past on studying the soil population dynamics of *A. flavus* in crop soils. As the fungal propagules transit in the kernels from field to storage, it is important to know the population density of *A. flavus* in the crop soils. Sudini *et al.* (2017) also reported that aflatoxin content in groundnut kernel were positively correlated with *A. flavus* in soil. Reducing the soil population density of *A. flavus* may help in managing pre-harvest aflatoxin contamination in groundnut. No information is available on the prevalence of *A. flavus* across major growing areas of Telangana

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state. Realizing the economic importance of the *A. flavus* and subsequent aflatoxin contamination, present investigation was carried out to know the distribution of *A. flavus* population and its relation with soil chemical and physical properties.

MATERIAL AND METHODS

A roving survey was conducted in major groundnut growing areas of Telangana during *rabi,* 2018-19 and *kharif,* 2019 to assess the population density of *A. flavus* and its relation with soil physical and chemical properties such as soil pH, soil organic carbon content and exchangeable calcium content.

Soil sampling

The rhizosphere soil samples were collected from each groundnut field in a sampling window of one week before harvesting to one week after harvesting. The soil samples at the depth of around 8-10 cm were collected from the field moving in zigzag manner and samples were pooled to draw a single representative sample. The soil samples were air-dried, ground and sieved under one mm sieve.

Assessment of *A. flavus* populations

A. flavus population in soil was enumerated using *Aspergillus flavus* and *parasiticus* agar specific medium (AFPA) by serial dilution technique (Nakrani *et al.,* 2015). Ten grams of soil was taken in 90 ml of sterilized distilled water and serially diluted upto 10^{-3} dilution. From this solution, one ml of soil suspension was added to petri plate and AFPA medium was poured and were incubated at 28 ± 1°C for three days. The colonies of *Aspergillus* started appearing after three days of incubation showing orange color on the back side of the petri dish were noted and number of colony forming units (cfu) were counted and expressed as cfu per gram of soil (cfu/g).

Determination of soil pH

Soil pH was determined by potentiometric method given by Jackson (1973). Twenty grams of soil was weighed and put into a clean 100 ml beaker. 40 ml of distilled water was added. The suspension was stirred for half an hour and pH (1:2) was recorded using a pH meter.

Determination of exchangeable calcium

Ten grams of soil sample was taken in 250 ml conical flask. To this 50 ml of 1 N ammonium acetate solution was added. The flasks were kept on mechanical shaker for 30 minutes period and later they were kept undisturbed overnight. The extract was filtered through Whatman No. 41 filter paper and filtrate was collected. Five ml of soil extract was pipetted out in a porcelain dish and 5 ml of NaOH (10%) and a pinch (50 mg) of murexide indicator was added. The solution was titrated against standard EDTA solution till colour changed from orange red to purple. Blank titration (without soil) served as control. Blank titre value was deducted from sample titre value to get actual titre value (Jackson, 1973).

Determination of soil organic carbon

Soil organic carbon was determined by wet oxidation method given by Walkey and Black (1934). One gram of soil sample was taken in 500 ml conical flask and 10 ml of 1 N Potassium dichromate solution ($K_2Cr_2O_7$) was added and mixed gently. 20 ml of Concentrated H_2SO_4 was added and swirled for 2 to 3 min and left for half an hour. 200 ml of distilled water was added. After that, 10 ml of 85% orthrophosphoric acid and 1 ml of diphenyl indicator was added which gave violet colour to the suspension. The content of the flask was titrated against 0.5 N ferrous ammonium sulphate solution taken in a burette till the colour changed from dark blue to bright green. Blank titration (without soil) was carried out and organic carbon content was calculated from sample and blank titre value.

Statistical analysis

All the experiments were carried out with three replications under controlled laboratory conditions. Data collected were analyzed by following completely randomized design (CRD). Pearson's correlation analysis was done to know the relationship between soil population of *A. flavus* and soil parameters using Web Agri Stat Package 2.0 developed by ICAR, New Delhi.

RESULTS AND DISCUSSION

Soil populations of *A. flavus*

The results indicated that significant variation in soil population density of *A. flavus* among collected soil samples ranged from 0 to 21.3×10^3 cfu/g with an average of 4.1×10^3 cfu/g of soil. The highest soil population density of *A. flavus* was recorded in soil sample MB-9 collected from Desaipally village of Mahabubnagar district (21.3×10^3 cfu/g). Surprisingly *A. flavus* colonies were not at all observed in some of the soil samples *viz.,* MB-5, NGK-7, NG-5 & WRG-1

collected from fields of Bheempur village of Mahabubnagar district, Turkalpally village of Nagarkurnool district, Dindi village of Nalgonda district and Nallabeli village of Warangal district (Table 1). Among different villages, the highest average population of *A. flavus* was observed in the Kyatanapalii village of Mahabubnagar district with 14.2×10^3 cfu/g and lowest was found in Nandigram village of Warangal district with 0.5×10^3cfu/g. If we take mandal as a unit, the highest average population of *A. flavus* was found in the Gandeed mandal of Mahabubnagar district with 11.8×10^3cfu/g of soil. On the other hand, Kalwakurthy mandal of Nagarkurnool and Wardhanapet mandal of Warangal district showed the lowest population of *A. flavus* with 1.1×10^3 cfu/g. District-wise data indicated Mahabubnagar district with the highest *A. flavus* populations of 7.8×10^3 cfu/g and Warangal district with the lowest *A. flavus* population of 1.5×10^3 cfu/g (Table 1 and Figure 1).

During *kharif,* 2019, the population of *A. flavus* among all the soil samples showed significant variation and it was ranged from 0 to 18.7×10^3 cfu/g of soil with an average of 4.5×10^3 cfu/g of soil. Highest population (18.7 cfu/g) was recorded in soil sample MB-6 collected from field of Mukthipahad village of Mahabubnagar district. *A. flavus* colonies were not observed in soil samples collected from Wademan and Peddamadanur villages of the Nagarkurnool district (Table 2). Among the different villages, the highest average population of *A. flavus* was found in the Mukhtipahad village (18.7×10^3cfu/g) of Mahabubnagar district and the lowest was found in Peddamadanur village (0.5 cfu/g) of Nagarkurnool district. Among the mandals, highest average population of *A. flavus* was found in the Kosgi mandal (9.2×10^3cfu/g) of Mahabubnagar district and Wardhanapet mandal of Warangal district showed the lowest population of *A. flavus* (1.3×10^3 cfu/g). The population of *A. flavus* was

Table 1. Mean populations of *A. flavus* in groundnut crop soils collected from different districts of Telangana state during *rabi,* 2018-19.

District	Mandal	Village	Sample No.	*A. flavus* population (× 10^3 cfu/g of soil)			
				Sample	Village	Mandal	District
Mahabubnagar	Damarigidda	Damrigidda	MB-1	1.3	4.2	9.2	7.8
			MB-2	7.0			
		Kyatanapalli	MB-3	12.3	14.2		
			MB-4	16.0			
	Maddur	Bheempur	MB-5	0.0	1.3	2.4	
			MB-6	2.7			
		Kazipur	MB-7	2.0	3.5		
			MB-8	5.0			
	Gandeed	Desaipally	MB-9	21.3	11.2	11.8	
			MB-10	1.0			
		Nancherla	MB-11	21.0	12.3		
			MB-12	3.7			
Nagarkurnool	Bijanpally	Boyapur	NGK-1	0.3	1.5	2.3	2.2
			NGK-2	2.7			
		Wademan	NGK-3	3.3	3.2		
			NGK-4	3.0			
	Kalwakurthy	Kalwakurthy	NGK-5	1.0	1.2	1.1	
			NGK-6	1.3			

District	Mandal	Village	Sample No.	*A. flavus* population (× 10^3 cfu/g of soil)			
				Sample	Village	Mandal	District
		Turkalapally	NGK-7	0.0	1.0		
			NGK-8	2.0			
	Nagarkarnool	Gaddampalle	NGK-9	0.7	1.3	3.0	
			NGK-10	2.0			
		Peddamadanur	NGK-11	3.7	5.2		
			NGK-12	6.7			
Nalgonda	Devarakonda	Mallepalli	NG-1	1.0	1.0	3.0	3.0
		Pendipakala	NG-2	7.7	4.0		
			NG-3	0.3			
	Dindi	Dindi	NG-4	1.3	0.7	3.6	
			NG-5	0.0			
		Gunakol	NG-6	8.3	5.3		
			NG-7	2.3			
Wanaparthy	Gopalpet	Buddaram	WNP-1	4.7	5.5	7.5	4.9
			WNP-2	6.3			
		Gopalpet	WNP-3	1.0	1.7		
			WNP-4	2.3			
	Pebbair	Bunyadpur	WNP-5	11.7	10.7	3.7	
			WNP-6	9.7			
		Pathapalle	WNP-7	7.0	4.3		
			WNP-8	1.7			
	Wanaparthy	Achytpur	WNP-9	1.0	1.8	7.5	
			WNP-10	2.7			
		Appaiyapalle	WNP-12	7.3	7.3		
Warangal	Nallabeli	Nandigram	WRG-1	0.0	0.5	3.7	1.5
			WRG-2	1.0			
		Relukunta	WRG-3	1.3	1.3		
	Narsampet	Dasaripally	WRG-4	1.0	1.0	2.6	
		Kammapally	WRG-5	6.0	3.3		
			WRG-6	0.7			
	Wardhanpet	Kakiralapally	WRG-7	1.3	0.8	1.1	
			WRG-8	0.3			
		Yellanda	WRG-9	1.7	1.7		
	Mean			**4.1**			
	SEm ±			**1.2**			
	CD (0.05)			**3.4**			

highest in soil samples of Mahabubnagar district (6.4×10^3 cfu/g) and lowest in Nagarkarnool district (2.8× 10^3 cfu/g) (Table 2 and Figure 1).

The variation observed in populations of *A. flavus* in different soils might be due to several reasons *viz.,* soil type, soil chemical properties, climatic condition, cropping pattern, soil microbial health and other agronomical practices. Similarly, Naik and Sudha (2009) who recorded highest population density of *A. flavus* (835.90 cfu/g soil) in Bellary district followed by Raichur district (677.00 cfu/g soil) and the lowest population density of 501.20 cfu/g soil was observed in Gulbarga district of Karanataka. Nakrani *et al*. (2015) also observed wide variation in population of *A. flavus* in the soils collected from different locations of North Gujarat with an overall range of 0.33 x 10^3 cfu/g to 9.00 x 10^3 cfu/g soil with an average of 4.92 x 10^3 cfu/g soil.

Effect of soil characteristics on *A. flavus* population

During *rabi,* 2018-19, the soil pH (1:2) was ranged from 5.87 to 8.01. The organic carbon content in the collected soil samples was ranged from 2.2 to 11.9% with an average of 5.5 g/kg. The exchangeable calcium content in the soil samples also ranged from 164 mg/kg to 2440 mg/kg with an average of 1138 mg/kg (Table 3). According to Pearson's correlation analysis, there was a significant negative correlation between calcium content of soil and soil population of *A. flavus* (*r* = - 0.46) while there was no significant correlation between organic carbon and soil pH with *A. flavus* population (Table 4).

During *Kharif,* 2019, the soil pH (1:2) ranged from 6.88 to 7.97. The organic carbon content ranged from 2.9 to 10.2 g/kg with an average of 0.64 %. The exchangeable calcium content in the soil samples also ranged from 181 mg/kg to 2536 mg/kg with an average of 994.78 mg/kg (Table 3). According to Pearson's correlation analysis, significant negative correlation was observed for *A. flavus* population with calcium content of soil and (*r* = - 0.46) and soil organic carbon (r = - 0.43) while there was no significant correlation between soil pH and *A. flavus* population (Table 4).

Table 2. Mean populations of *A. flavus* in soil collected from different districts of Telangana state during *kharif,* 2019.

District	Mandal	Village	Sample No.	*A. flavus* population (× 10^3 cfu/g of soil)			
				Sample	Village	Mandal	District
Mahbubnagar	Damarigidda	Damarigidda	MB-1	3.7	7.7	6.6	6.4
			MB-2	11.7			
		Bapanapalli	MB-3	4.3	4.3		
	Maddur	Bheempur	MB-4	1.3	1.3	1.8	
		Kazipur	MB-5	2.3	2.3		
	Kosgi	Mukhtipahad	MB-6	18.7	18.7	9.2	
		Kadampally	MB-7	6.3	4.5		
			MB-8	2.7			
Nagarkurnool	Bijanpally	Boyapur	NGK-1	1.3	1.8	1.8	2.8
			NGK-2	2.3			
		Wademan	NGK-3	0.0	1.8		
			NGK-4	3.7			
	Lingal	Lingal	NGK-5	6.7	6.7	4.6	
		Ausalkunta	NGK-6	2.3	3.5		
			NGK-7	4.7			

District	Mandal	Village	Sample No.	*A. flavus* population (× 10^3 cfu/g of soil)			
				Sample*	Village	Mandal	District
	Nagarkarnool	Deshitkyal	NGK-8	3.0	4.5	2.5	
			NGK-9	6.0			
		Peddamadanur	NGK-10	1.0	0.5		
			NGK-11	0.0			
Nalgonda	Kanagal	Chinnama-daram	NG-1	7.3	4.8	3.7	4.0
			NG-2	2.3			
		Darveshpuram	NG-3	1.3	1.3		
	Nalgonda	Cherlapally	NG-4	2.7	2.7	4.7	
		M. Domalapally	NG-5	6.7	6.7		
	Dindi	Gunakol	NG-6	3.7	3.7	3.7	
Wanaparthy	Gopalpet	Gopalpet	WNP-1	9.0	10.3	8.5	5.7
			WNP-2	11.7			
		Buddaram	WNP-3	3.7	6.7		
			WNP-4	9.7			
	Pangal	Mahammada-pur	WNP-5	2.3	4.3	3.5	
			WNP-6	6.3			
		Chintakunta	WNP-7	4.3	2.6		
			WNP-8	1.0			
	Wanaparthy	Appaiyapalle	WNP-9	3.3	3.3	4.8	
		Chityala	WNP-	7.7	5.5		
			WNP-	3.3			
Warangal	Nallabeli	Rudragudem	WRG-1	7.0	8.0	5.8	3.7
			WRG-2	9.0			
		Lenkanapally	WRG-3	1.3	1.3		
	Narsampet	Dasaripally	WRG-4	3.7	3.7	4.0	
		Kammapally	WRG-5	7.3	4.2		
			WRG-6	1.0			
	Wardhanpet	Kakiralapally	WRG-7	1.0	1.5	1.3	
			WRG-8	2.0			
		Yellanda	WRG-9	1.0	1.0		
	Mean			**4.5**			
	SEm ±			**0.9**			
	CD (0.05)			**2.4**			

* Mean of three replications

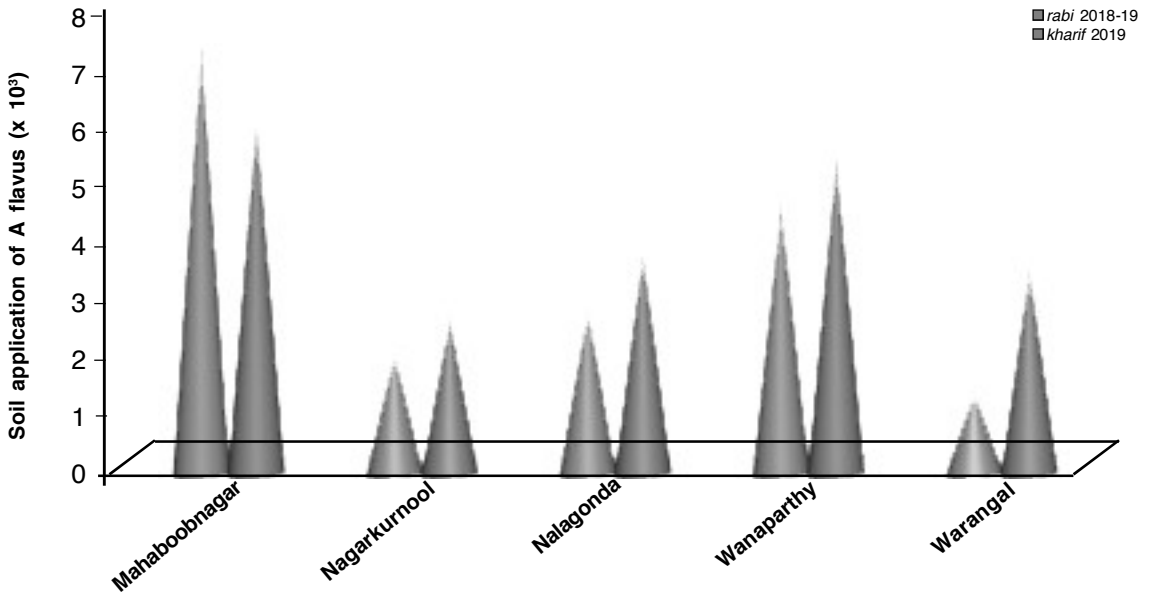

Fig. 1. District wise average soil populations of *A. flavus* in Telangana state

In the present study, it was observed that there was significant negative correlation between exchangeable calcium content in soil and soil population of *A. flavus* indicating that increase in calcium level in soil decreases the population density of *A. flavus* which might be due to fungistatic nature of calcium by delaying the spore germination. It was supported by Alam *et al.* (2010) who reported that calcium propionate at 1% concentration inhibited the growth of *A. flavus* (A-2092) under *in vitro* on Czapek yeast extract agar and delayed the germination process of spores for up to 10 days. Increase in soil organic carbon increases the fungal antagonistic microflora in soil which affects the *A. flavus* growth. A report by Waliyar *et al.* (2007) suggested that application of lime as source of calcium can provide effective control of *A. flavus* infection and reduced aflatoxin levels by 79% in groundnut susceptible variety JL 24. In contrary, there was no significant relationship between soil pH and *A. flavus* population. Whereas soil carbon showed difference in correlation study between seasons (Significant negative correlation in *kharif* and no correlation in *rabi*) which might be due to multi-level interactions among soil carbon, *A. flavus* populations

Table 3. Analysis of soil samples collected from different groundnut growing locations of Telangana state during *rabi,* 2018-19 and *kharif,* 2019.

Sl. No	Soil parameter	*Rabi,* 2018-19		*Kharif,* 2019	
		Range	Average	Range	Average
1.	Soil pH (1:2)	5.87 to 8.01	7.42	6.88 to 7.97	7.49
2.	Organic carbon (g/kg)	2.2 to 11.9	5.5	0.29 to 1.02	0.64
3.	*Exchangeable calcium	164 to 2440	1138	181 to 2536	994.78

* Includes water soluble calcium also

Table 4. Correlation between soil properties and *A. flavus* populations in soil collected from different districts of Telangana state during *rabi* 2018-19 and *kharif* 2019.

Correlation	*A. flavus* populations	
	Rabi, 2018-19	*Kharif,* 2019
Soil pH	-0.03	0.004
Soil organic carbon	-0.11	-0.43**
Soil exchangeable Calcium	-0.46**-	0.39**

**** Significant at 5 % level of significance**

and antagonistic organisms in soil. Thus in general, it can be stated that higher calcium and organic carbon in soil will reduce *A. flavus* infection in groundnut kernels.

CONCLUSION

Our present investigation revealed variations in the distribution of *A. flavus* populations among the groundnut growing districts of Telangana state. Mahabubnagar district was found to have highest soil populations of *A. flavus.* Exchangeable calcium content in soil was found to have controlling effect on *A. flavus* populations. In order to reduce *A. flavus* populations in groundnut crop soil and subsequent aflatoxin contamination in groundnut kernels, it is suggested to follow good agricultural practices such as application of fungal antagonistic microorganisms (*Trichoderma, Bacillus,* and *Pseudomonas*), application of calcium sources like gypsum/lime and crop rotations.

ACKNOWLEDGEMENT

The work reported in this article was undertaken as a part of the CGIAR Research Program on Grain Legumes and Dryland Cereals (CRP-GLDC). ICRISAT is a member of the CGIAR consortium.

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Research Article
The J. Res. PJTSAU 49 (1&2) 25-29, 2021

GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR YIELD AND ITS COMPONENT TRAITS IN GERMPLASM LINES OF RICE (*Oryza Sativa* L.)

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Date of Receipt : 27-03-2021 Date of Acceptance : 12-04-2021

ABSTRACT

The present investigation was carried to know the extent of genetic variability in sixty-five germplasm lines of rice collected from all over India, for yield and yield attributing characters. Analysis of variance revealed highly significant differences for all the 10 characters, indicating the presence of genetic variability among the genotypes. The present investigation revealed that the estimates of PCV were slightly higher than GCV for all the characters studied indicating less influence of environmental factors on the expression of traits and the possibility for genetic improvement through direct selection for these traits. The magnitude of PCV and GCV estimates were moderate for three traits *viz.,* days to 50% flowering, plant height, panicle length, total number of tillers per plant, effective number of tillers per plant and test weight, indicating the influence of environment rather than the genotype alone. The heritability and genetic advance estimates were moderate for panicle length and high for all the other traits *viz.,* days to 50% flowering, plant height, total number of tillers per plant, effective number of tillers per plant, panicle weight, number of filled grains per panicle, number of unfilled grains per panicle, test weight and single plant yield indicating the influence of additive gene action, as such selection would likely be effective for improvement of these traits.

Rice is one of the most important cereal crops of the world meeting the dietary requirements of the people living in the tropics and sub-tropics. It is the staple food for over half the global population. The quantum jump in yield improvement has been achieved in rice with the development of high-yielding heterotic hybrids. However, improving its productivity has become crucial to meet the growing population of the world which is anticipated to reach 9-11 billion during 2030- 2050 (Subbaiah *et al.*, 2011). With the current trends of growing population and agricultural production, the demand for food in most parts of the world will nearly triple by the year 2030. Crop yield improvement is of prime importance to fulfill the demands owing to a constant increase in population.

A critical analysis of genetic variability present in a given crop species is a prerequisite for initiating any crop improvement programme and for adoption of appropriate selection techniques. Estimates of heritability will be of immense help to the breeder in selecting for a desired trait from superior individuals for successful utilization in the breeding programme. Genetic advance measures the difference between the mean genotypic values of selected population and the original population from which these were selected. Heritability estimates along with genetic advance are more helpful in predicting the gain under selection. (Johnson *et al.* 1955). Keeping in view of the above perspectives, the present investigation is carried out with the objective of estimating the genetic variability for yield, yield contributing traits, heritability and genetic advance which would help in selection and further improvement of rice genotypes.

MATERIAL AND METHODS

Sixty-five (65) rice germplasm lines collected from all over India were evaluated for yield and component traits during *Kharif* 2019 in Randomized Block Design (RBD) with two replications at ICAR-Indian Institute of Rice Research (ICAR-IIRR), Rajendranagar, Hyderabad. Thirty days old seedlings were transplanted by adopting a spacing of 15 cm between plants and 20 cm between rows. Recommended agronomic and plant protection measures for raising a healthy nursery and main crop were taken up during the experiment. Observations were recorded on five randomly selected plants in each genotype in each replication for ten quantitative traits *viz.,* days to fifty percent flowering (DFF), plant height (PH) (cm), panicle length (PL) (cm), tillers per plant (TN),

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Effective number of tillers per plant (ENT), panicle weight (PW) (g), number of filled grains (NFG), number of un-filled grains (NUFG), thousand grain weight (TW) (g) and single plant yield (SPY) (g). The mean of five plants for each metric trait was considered for statistical analysis using SAS software. The analysis of variance (ANOVA) was done on the basis of model described by Cochran and Cox (1950) for randomized block design. The genotypic and phenotype variances were calculated as per the formulae proposed by Burton and Devane, 1953. Heritability in broad sense (h^2) was calculated by the formula given by Lush, 1949 as suggested by Johnson *et al.* (1955). From the heritability estimates, the genetic advance (GA) was calculated by the formula given by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among the 65 germplasm lines for all the 10 characters (Table 1) indicating the presence of adequate amount of genetic variability among the genotypes assessed. The genotypic and phenotypic coefficients of variation, heritability and genetic advance as per cent of mean were estimated for and the details are furnished in table 2. The graphical representation of variability parameters is depicted in Fig 1 and Fig 2.

The present investigation revealed that the estimates of PCV were slightly higher than GCV for all the characters studied indicating less influence of environmental factors on the expression of traits. As the characters were less influenced by the environment, the traits can be used for selection. The magnitude of PCV and GCV estimates were moderate for three traits *viz.,* days to 50% flowering, plant height, panicle length, total number of tillers per plant, effective number of tillers per plant and test weight. Similar such observations were made by Mishu *et al*., (2016) for days to 50% flowering and panicle length in six aromatic rice varieties, Lakshmi *et al*., (2017) for plant height and Devi *et al.,* (2016) for test weight.

High estimates of GCV and PCV were observed for panicle weight, number of filled grains, number of unfilled grains and single plant yield. Similar findings were reported by Bagudam *et al.* (2018) for plant height in NPT core rice collections and Shivani *et al*., (2018) for number of filled grains, number of unfilled grains and single plant yield in Swarna x Type 3 RIL population of rice. Parimala *et al*., 2020 reported similar estimates for number of filled grains and number of unfilled grains per panicle. In similar to our findings, the above reported observations for high GCV and PCV estimates for important yield component traits, does indicate the possibility for genetic improvement through direct selection for these traits.

Heritability measures the contribution of genetic variability to the phenotypic variability and is a good index of the transmission of characters from parents to their offspring. The estimates of heritability can be utilized for prediction of genetic gain, which indicates the genetic improvement that would result from selection of best individuals. Genetic advance (GA) is the measure of genetic gain under selection. Heritability estimates along with genetic advance are normally more helpful in predicting the genetic gain under selection than heritability estimates alone.

High heritability coupled with high genetic advance estimates were recorded for all the traits *viz.,* days to 50% flowering, plant height, total number of tillers per plant, effective number of tillers per plant, panicle weight, number of filled grains per panicle, number of unfilled grains per panicle, test weight, single plant yield except panicle length. These results are in conformity with Tiwari *et al*., (2019) for days to 50% flowering, Shivani *et al*., (2018) for plant height and single plant yield in Swarna x type 3 RIL population.

Table1. Analysis of variance for yield and its component traits among rice genotypes

Source of Variation	d. f	DFF	PH	PL	TNT	ENT	PW	NFG	NUFG	TW	SPY
Replication	1	1.10	6.07	5.44	0.33	0.15	0.004	10.0	0.69	0.49	4.10
Treatment	64	26447.8 *	26227.0 *	364.2 *	624.8 *	521.4 *	77.7 *	95061.4 *	15045.0 *	1353.4 *	1704.5 *
Error	64	40.8	115.1	18.2	49.5	38.5	3.40	208.4	38.21	42.03	34.8

*Significance at 5% level

DFF- Days to 50% flowering, PH- Plant height, PL- Panicle length, TNT- Tillers number per plant, ENT- Effective number of tillers per plant, PW- Panicle weight, NFG- Number of filled grains, NUFG- Number of unfilled grains, TW- Test weight, SPY- Single plant yield.

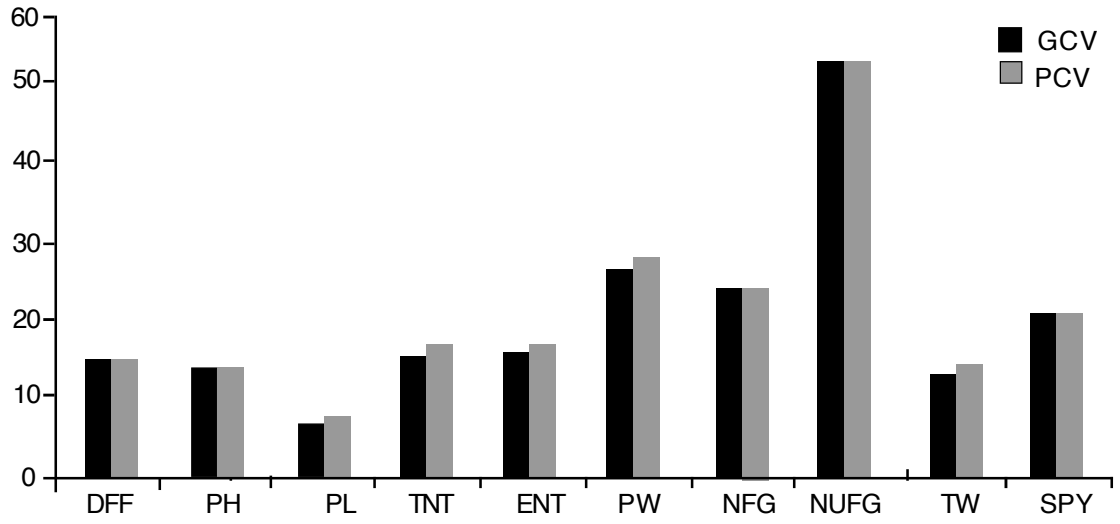

Fig 1. Graphical representation of PCV and GCV

Similar findings were reported by Bagudham *et al*., (2018) for total number of tillers per plant in NPT core rice accessions, Sudeepthi *et al*., (2020), Shivani *et al*., (2018) for total number of tillers per plant and Parimala *et al*., (2020), Shivani *et al*., (2018) for test weight, which support the present findings. This indicates that there was low environmental influence on the expression of these characters and hence one can practice selection. Whereas, high heritability coupled with moderate genetic advance was observed for panicle length. Similar findings were reported by Mohan *et al*., (2016) for panicle length indicated that this trait could be potentially improved by selective breeding.

The genetic architecture of grain yield is based on the overall net effect produced by various yield components interacting with one another. The present investigation revealed that there is adequate genetic variability present in the germplasm lines studied. Among all the characters, days to 50% flowering, plant height, total number of tillers per plant, effective number of tillers per plant, panicle weight, number of filled grains per panicle, number of unfilled grains per panicle, test weight and single plant yield recorded high heritability as well as high genetic advance, indicating the presence of considerable variation and additive gene effects. Hence, improvement of these characters could be effective through phenotypic selection.

Table 2. Variability parameters in rice genotypes

S. No	Characters	General	Range	Coefficient of variation (%)		Heritability in broad sense (h^2) %	Genetic Advance percent of mean (at 5%)
				GCV (%)	PCV (%)		
1	DFF	98.031	63-130	14.65	14.67	99.69	30.13
2	PH	104.748	80-157	13.63	13.69	99.12	27.96
3	PL	24.252	20.7-31.4	6.77	7.12	90.43	13.28
4	TNT	13.729	8.3-22.3	15.44	16.71	85.29	29.37
5	ENT	12.221	7-19	15.89	17.11	86.2	30.39
6	PW	2.863	1.2-5.5	26.62	27.81	91.61	52.50
7	NFG	112.167	54.6-223.2	24.26	24.32	99.56	49.88
8	NUFG	19.819	4-50	54.63	54.77	99.49	112.25
9	TW	23.557	11.4-29.8	13.58	14.01	93.97	27.13
10	SPY	17.176	9.7-27.7	21.02	21.46	95.99	42.4

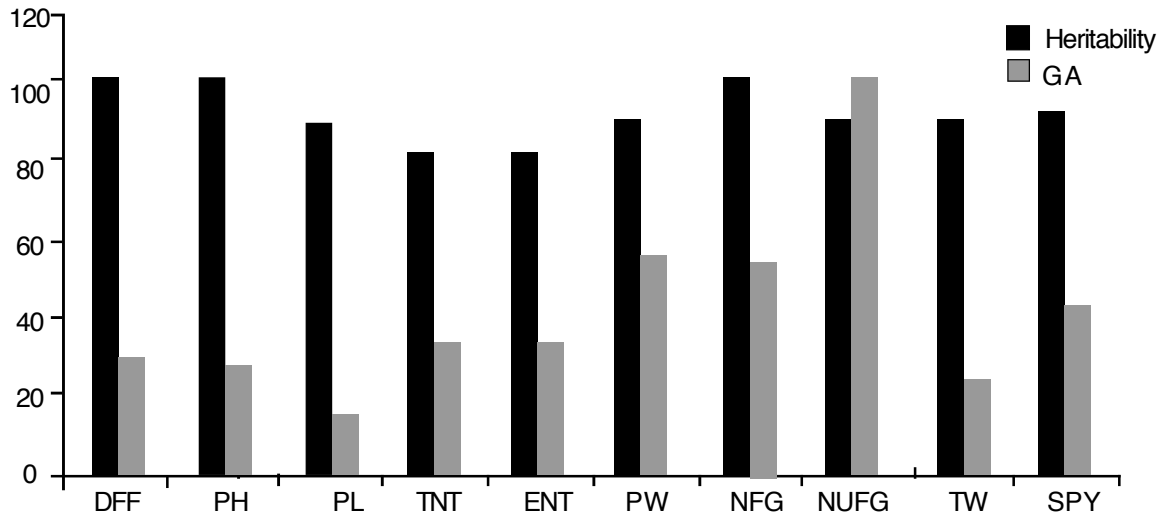

Fig 2. Graphical representation of hritability (board sense) and genetic advance as per cent of mean (5%)

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Research Article
The J. Res. PJTSAU 49 (1&2) 30-37, 2021

KODANGAL FARMER SERVICE PRODUCER COMPANY- A CONSTRAINT ANALYSIS

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Date of Receipt : 16-03-2021 Date of Acceptance : 20-04-2021

ABSTRACT

Farmer Producer Organisations is a crucial strategy for creating an ecosystem for enhancing farmers profits. Ex-post facto research design was adopted to examine the constraints faced by different stake holders involved in formation and operationalisation of Kodangal Farmer service Producer Company (KFPC) in Telangana state. Data was collected from 30 member farmers, 30 non-member farmers, 10 Board of Directors (BoDs) and 12 officials of the FPC. Hence, total samples becomes 82. Garrett tanking technique of constraint analysis showed that lack of awareness among farmers and socio-cultural barriers were the major problems faced by the supporting institution and Board of Directors (BoDs) at the time of formation of FPC. During operationalisation, lack of adequate number of godowns, store houses, illiteracy, weak educational exposure in maintaining accounts and records were the major hindering factors for supporting institution and BoDs respectively. Irregular procurement of produce was the major operational constraint opined by the member farmers. High cost of labour and lack of assured procurement facilities were the major labour and economic and marketing constraints respectively.

Small Farmers' Organizations such as cooperatives and FPOs are expected to enhance incomes, reduce costs of input purchases along with transaction costs, create opportunities for involvement in value-addition including processing, distribution and marketing, enhance bargaining power and provide access to formal credit (Agarwal, 2010). The year 2014 is being observed as the "Year of Farmer Producer Organisations (FPOs)" by Government of India. Small Farmers' Agribusiness Consortium (SFAC) is recognised as the nodal agency by the Government of India in the promotion of FPOs in the country.

The number of farmers linked are 8,78,406 to 886 FPOs in India. Whereas, in Telangana 29,848 farmers were linked to 25 SFAC promoted FPOs (http://sfacindia.com/State-Level-Producer-Companies.aspx). Kodangal Farmer service Producer company is one amongst them.

The Access Livelihood Corporation (ALC), a social enterprise has started the mobilization of the SHG women farmers. After sensitisation, the interested members registered under companies act 1956 as Kodangal Farmer Service Producer company with a corporate ID U01400AP2013P TC086781 on 3rd April, 2013 which was a pulse-based company. Some of the lead farmers were selected as Representative General Body (RGB) leaders and Board of Directors (BoDs), president and vice president *i.e.,* it is a four-tier structure. Kodangal village of Kodangal mandal of Vikarabad district was selected as the centre of operation due to the advantage of flexibility in operations and transportation facilities. KFPC is operating in 10 villages with 1022 women farmer shareholders.

From the formation stage, KFPC was involved in providing various services to the farmers like input supply (fertilizers and pesticides) on credit and cash basis, technical advice on farming practices, collective procurement of red gram, exposure visits and women empowerment services etc. During this process, different stakeholders faced several challenges. Hence, an attempt has been made to analyse the lacunae in formation and operationalisation of FPC.

MATERIAL AND METHODS

Ex-post facto research design was adopted for the study. The state of Telangana and Kodangal FPC was selected purposively. Data was collected for the year 2018-19. Three villages having highest number of member farmers were selected from Kodangal mandal of Vikarabad district. Ten member farmers and ten non-member farmers (women farmers) selected from each village. Ten BoDs and 12 officials

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who are working closely with KFPC were selected. Hence, the total sample becomes eighty-two for the study. Garrett ranking technique was used to rank the problems faced by different stakeholders during the formation and operationalisation of various activities of FPC. In the Garrett's scoring technique, the respondents were asked to rank the factors or problems and these ranks were converted into per cent position by using the formula.

Where,

$$\text{Percent Position} = 100 \times \frac{(R_{ij} - 0.5)}{N_j}$$

R_{ij} = Ranking given to i^{th} attribute by the j^{th} individual.

N_j = Number of attributes ranked by the j^{th} individual.

By referring to the Garrett's table, the percent positions estimated were converted into scores. Thus, for each factor the scores of the various respondents were added and the mean values were estimated. The mean values thus obtained for each of the attributes were arranged in descending order. The attributes with the highest mean value were considered as the most important one and the others followed in that order.

RESULTS AND DISCUSSION

The FPC confronted with several challenges during formation and operationalisation. The supporting institution and lead farmers *i.e.,* the then BoDs encountered problems while forming FPC. Also, many challenges were faced by supporting institution, BoDs and members during operationalisation of FPC. The results were presented below.

I. Constraints faced at the time of formation

Supporting institution and BoDs faced several problems during formation stage and the results were presented below.

It is noted from Table 1 that, lack of awareness among farmers (73.17) about collective action through FPC was the major constraint faced by the ALC officials who were involved in mobilizing the farmers. This was mainly due to lack of proper education and social mobility among the women farmers to comprehend the new activities. Similar results were found in the study of Bharathi (2005).

The major constraint faced by the BoDs as it is observed from Table 2 was the socio-cultural barriers with a mean score of 78.80. This was mostly in light of the fact that, BoDs confronted trouble in creating awareness about the organization which was going to be headed by women farmers in the male dominated society where the women need to play the positions of authority. These findings were inconformity with the results of Onugu Charles Uchenna (2016).

Table 1. Constraints faced by supporting institution

S.No.	Particulars	Garrett score	Rank
1	Lack of own office building	68.63	2
2	Lack of availability of literature	33.08	6
3	Delay in license	43.08	5
4	Inadequate trained staff	59.92	3
5	Lack of awareness among farmers about FPC	73.17	1
6	Lack of volunteerism	48.75	4
7	More administrative control	24.08	7

Table 2. Constraints faced by Board of Directors (BoDs)

S.No.	Particulars	Garrett score	Rank
1	Socio-cultural barriers	78.80	1
2	Difficulty in convincing the members	66.30	2
3	Non-cooperation from the family members	59.70	3
4	Lack of reimbursement of money spent for group purposes	38.80	6
5	Delay in registration of FPO	45.35	5
6	In appropriate guidance from NGO	27.15	8
7	Perception of people towards women	37.00	7
8	Poor access to extension services	47.5	4

I. Constraints faced in operationalisation

The operationalisation constraints were analysed for supporting institution, BoDs, members and non-member farmers.

The constraints of supporting institution were divided into technical and operational, marketing and financial constraints.

The Table 3 illustrates that lack of own office building (67.91) was the major technical and operational constraint. This physical difficulty posed problem in conducting meetings to the BoDs and RGB leaders regarding the functional aspects of FPO. This constraint was followed by inadequate trained staff (64.16) for providing required information to the members. These findings were in agreement with the findings of Gundlach (2013).

Lack of adequate number of godowns and store houses (69.16), followed by lack of adequate vehicles for transport (63.33) were the major marketing constraints faced by the institution. This resulted in

Table 3. Constraints faced by the supporting institution

S.No.	Particulars	Garrett score	Rank
	Technical and Operational		
1	Lack of own office building	67.91	1
2	Lack of availability of literature	27.87	5
3	Inadequate trained staff	64.16	2
4	Lack of volunteerism	49.00	3
5	More administrative control	39.54	4
	Marketing		
1	Lack of adequate number of godowns and store houses	69.16	1
2	Lack of facilities for transport	63.33	2
3	Lack of processing facility	50.75	3
4	Organisation is far away from market	26.58	5
5	Difficulty to meet export standards	38.66	4
	Financial		
1	Lack of enough capital	61.08	1
2	Lack of willingness of members to contribute for raising capital	53.16	2
3	Meagre contributions for savings by members	35.75	3

Table 4. Constraints faced by Board of Management

S.No.	Particulars	Garrett score	Rank
1	Illiteracy and poor educational exposure in maintaining accounts and records	76.75	1
2	Lack of capital	62.85	2
3	Household responsibilities	59.15	3
4	In appropriate guidance from NGO	24.50	7
5	In appropriate timings of the meetings	44.00	5
6	Perception of people towards women	50.75	4
7	Lack of cooperation from members	32.00	6

higher costs for input and output marketing. To overcome this, the officials opined for provision of better infrastructural facilities by the state and central governments to the FPCs for the improved efficiency.

Lack of enough capital (61.08) to expand the business activities was the major financial constraint. The officials opined that provision of adequate capital support by the donor agency and supportive environment will improve the viability of FPC in the long run which facilitates diversification of business and value addition. These results were in agreement with the results of Bhattacharjee (2010).

It was clear from the Table 4 that illiteracy and weak educational exposure is the major constraint in maintaining the accounts and records (76.75) accurately and transparently. This was followed by lack of capital and household responsibilities with a Garrett score of 62.85 and 59.15 respectively.

II. Constraints faced by members

The constraints experienced by the members were divided into organisational constraints, constraints related to supporting institution and farm level constraints.

For the organisational constraints, the constraints were categorized into technical and operational, competition and conflict constraints. For the farm level constraints, the constraints were divided into technical and operational, labour and economic constraints and marketing constraints. The farm level constraints were analysed for both members and non-members and they were presented below.

i. Organisational constraints

Irregular procurement of the produce with a mean score of 79.00 was the major problem. This was due to absence of consistent procurement policy by central and state governments due to which procurement licenses were shifted between societies under Gram Panchayat (state government) and NCDEX of SFAC (central government). Procurement by FPOs was beneficial as the payments were made within 10 days. But the payments took up to one month in case of societies. Hence, the shareholders felt that FPOs should be permitted every year for procurement of their produce.

Personal gain is of utmost importance than the group goals (62.20) was the major constraint as seen in Table 6. This was observed in case of availing inputs on credit and cash basis from the FPC. This problem was followed by competition among villages (60.40) and strive against each other over benefit sharing (59.73).

This was followed by competition among villages (60.40) and strive against each other over benefit sharing (59.73). The inputs were distributed on credit basis to the villages that are having good repayment capacity. In addition, the villages that were close to the FPC were provided with inputs regularly at an early crop period when compared to remote villages. Hence, there exists the opinion of competition among villages.

It is observed from the Table 7 that competing over resources like fertilizer use (62.00) and stealing

Table 5. Technical and operational constraints of sample member farmers

S.No.	Particulars	Garrett score	Rank
1	Irregular procurement of produce	79.00	1
2	Organisation takes produce of non-members	23.20	8
3	Inadequate storage facilities	66.78	2
4	Inadequate transportation facilities	36.30	6
5	Lack of leader cooperation	52.40	4
6	Lack of availability of literature	46.97	5
7	Political interference	33.63	7
8	Lack of adequate staff	61.72	3

Table 6. Constraints related to competition by sample member farmers

S.No.	Particulars	Garrett score	Rank
1	Oppose each other in meetings	36.80	7
2	Each tries to achieve key positions in the organisation	34.85	8
3	Competition among villages over benefit sharing	60.40	2
4	Strive against each other over benefit sharing	59.73	3
5	Less supportive in organisational activities	53.12	4
6	Personal gain is of utmost importance than the group goals	62.20	1
7	Lack of team spirit	52.90	5
8	Governing board is not uniform	40.40	6

Table 7. Constraints related to conflicts by the sample member farmers

S.No.	Particulars	Garrett score	Rank
1	Clash among members over activity selection	52.88	5
2	Have divergent views in village meetings	53.01	4
3	Become aggressive over benefit sharing	59.66	3
4	Compete over resource use	62.00	1
5	Challenge each other for key positions in the group	34.78	8
6	Try to remove opponent persons from the group	40.40	6
7	Stealing resources for personal gain	60.35	2
8	Serious hostility/ violence in organizational issues	36.80	7

resources for personnel gain (60.35) were the major problems faced by the members in the FPO. This was observed in availing fertilizers during crop growth period. These results were in conformity with the results of Raghuprasad (2004).

This was followed by becoming aggressive over benefit sharing (59.66), having divergent views in village meetings (53.01) and clash among members over activity selection (52.88).

ii. Constraints related to supporting institution

It is understood from Table 8 that the respondents perceived some of the problems related to supporting institution and found that profit motive (74.50), followed by focusing only on progressive farmers (58.16) were the major constraints. Though FPC is lending nominal interest money, members compared this with other lending groups like SHGs and opined that the FPC is doing this to gain profits. Esham and

Table 8. Constraints related to supporting institution

S.No.	Particulars	Garrett score	Rank
1	Focussing their own agenda on FPOs	52.33	3
2	Profit motive	74.50	1
3	Focussing only on progressive farmers	58.16	2
4	Interfere in the decision-making process of FPOs	35.88	4
5	Unable to guide field mobilizers	25.55	5

Usami (2007) also reported that perception of farmers about farmer company as a service provider and the awareness gap resulted in low farmers participation in the farmers supported activities.

iii. Farm level constraints of sample farmers

The farm level constraints were analysed for both members and non-members

The perusal of Table 9 indicates that, among the technical and operational constraints, lack of infrastructural facilities like irrigation and implements were the major problems faced by both members (71.47) and non-members (76.33) in the study area. The lack of irrigation facilities forced them to depend on rainfall in kharif season and leaving most of the farmers non-cultivators in rabi season. These findings were inconformity with the results of Chandargi (2007) and Ankur Adhikary (2020).

It was observed from the Table 10 that high cost of labour (66.47) was the major constraint faced by both members (74.67) and non-members (65.73) in the study area. This was followed by unavailability of labour during harvesting. These findings were in agreement with the results of Shashikant *et al.* (2012).

The Table 11 explains that, lack of assured market facilities (75.50) was the major constraint faced by the members. This was followed by fluctuation in market price (67.73) and delayed payment (56.53). This was mainly because of irregular involvement of FPC in red gram marketing due to fluctuation in market prices. The farmers also expressed that unlike red gram procurement, the other crops like cotton and paddy were

Table 9. Technical and operational constraints at farm level by sample farmers

S.No.	Particulars	Members		Non-Members	
		Garrett score	Rank	Garrett score	Rank
1	Untimely, costly and poor-quality inputs	45.53	5	33.22	6
2	Lack of processing facilities	63.03	2	67.17	2
3	Lack of proper infrastructure (implements, irrigation facilities etc.)	71.47	1	76.33	1
4	Lack of awareness on new farming methods	55.17	3	49.50	4
5	Difficulties in following the recommended practices	54.27	4	42.45	5
6	Computer illiteracy which makes them unable to derive benefits of the ICT tools available	35.58	6	57.25	3
7	Lack of awareness about grading and packaging	26.90	7	24.08	7

Table 10. Labour and economic constraints of sample farmers

S.No.	Particulars	Members		Non-Members	
		Garrett score	Rank	Garrett score	Rank
1	Unavailability of labour during harvesting	65.03	2	61.30	2
2	Lack of technical skill of labourers in harvesting, processing	53.73	3	41.90	5
3	High cost of labour	74.67	1	65.73	1
4	Lack of financial support	46.25	4	58.50	3
5	Unawareness of credit facilities	32.32	5	45.78	4
6	No crop insurance facilities	27.50	6	25.25	6

not being taken by FPC. The farmers were of the opinion that the provision of the assured market facilities for all of their produce as single outlet by FPC would give a sense of satisfaction for their work. These results were in agreement with the findings of Chandargi (2007) and Shivani *et al.* (2017).

The major marketing constraint faced by the non-members from Table 11 was exploitation by the middlemen with a mean score of 74.25, followed by lower price for the produce and distress sale (65.83). This may be due to the presence of relation of farmers with commission agents who were providing them financial support for purchasing inputs. In order to clear the debts, the farmers were selling their produce to them at lower price and at higher rates of interest. In addition, the commission agents also make the payments immediately which was the main attracting factor for the farmers in the study area to sell their produce to same.

Table 11. Marketing constraints of sample farmers

S.No.	Particulars	Members		Non-Members	
		Garrett score	Rank	Garrett score	Rank
1	Exploitation by middle men	50.00	4	74.25	1
2	Lack of latest market information	26.50	7	49.75	4
3	Lower price for produce and distress sale	43.53	5	65.83	2
4	Distant market and high cost of transportation	32.15	6	22.90	7
5	Price fluctuation over the years	67.73	2	60.92	3
6	Lack of assured procurement facilities	75.50	1	41.82	5
7	Delayed payment	56.53	3	35.53333	6

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Research Article
The J. Res. PJTSAU 49 (1&2) 38-42, 2021

IMPACT OF PRECIPITATION ON YIELDS OF MAJOR CROPS IN TELANGANA - A DISTRICT WISE ANALYSIS

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ABSTRACT

Climate change is a long-term phenomenon in the statistical distribution of weather patterns over a region. It causes changes in weather parameters like temperature and precipitation. Precipitation changes would have consecutive effects on water resources, soil moisture, agricultural activities, irrigation schedules, soil erosion etc. (Zamani *et al.,* 2018). Rainfall, being a crucial parameter of climate change influences the crop production in terms of quantum of rainfall received and its distribution. To understand its variability in distribution, seasonal PCI was calculated at district level for the state of Telangana over the past 30 years (1988-2017). The outcomes indicated that all the regions have moderate PCI esteems (11 to 15) and high PCI esteems (16 to 20) in dispersion of precipitation. The high concentration of the PCI implied that the distribution of rainfall is not uniform and highly concentrated in some years. Further, the study has examined the impact of PCI on yield of three major crops (rice, maize and cotton) and revealed that the relationship between PCI and crop yields of rice and maize are found to be non-significant in all the districts. While cotton was found to have significant yield reduction with increased PCI was observed in Khammam, Nalgonda, Nizamabad, Rangareddy and Warangal districts as cotton is more sensitive crop to rainfall in both the shortfall and excessive rainfall case.

Agriculture provides livelihood to more than half of the Telangana state's workforce and is crucial for restoring rural economy. Three major crops in Telangana, which occupied 70% of the cropped area are rice, cotton and maize. Among these major crops, cotton even surpassed area under rice especially years characterized by low rainfall as cotton has advantage of being cultivated under non-irrigated conditions in majority of its area during 2014. According to Rehana *et al.* (2018) the frequency of severe and wide spread multi-year droughts are due to erratic summer monsoon and increase in air temperature, creating huge damage to crops and society. Telangana is prone to frequent droughts, resulting in distress among farming community and witnessed frequent incidences of droughts and crop failures leading to farmer's suicides (Socio-economic outlook 2018). Crop failure due to drought has resulted in 342 farmers committed suicides in 2015 as reported by the Ministry of Agriculture. Rapid climate change with low erratic rain and high diurnal temperatures resulted in frequent droughts especially in Mahabubnagar, Warangal and Nalgonda districts which had impacted on the state's agriculture making it vulnerable. Rainfall is one of the key climate parameters as it requires large volume of water for crop production. The production and yield have direct dependency on timeliness, quantum of rainfall received and its distribution during the crop season. Heavy rains with low frequencies will result in water logging and decrease the yield, on other side inadequate rainfall causes water stress which affects the size of inflorescence, grain filling lead to terminal stress and ultimately reduces the yield. The behavior of the climate parameters for a thirty-year period (1988 to 2017) in terms of mean values average in respect of the climatic variables rainfall is considered. Similarly, Precipitation Concentration Index (PCI) is calculated to understand the fluctuations in rainfall over a period of 30 years (Ezenwaji *et al*, 2017). In the present study an attempt has been made to analyze the rainfall behavior and its distribution. In addition, correlation of yield across districts and PCI for rice, maize and cotton was arrived to capture the recurrent nature of precipitation.

MATERIAL AND METHODS

Study Area

Telangana State is divided into three agroclimatic zones based on climate, rainfall and nature of soils namely, Southern - Telangana Zone

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(Rangareddy, Mahabubnagar, Nalgonda, North western part of Warangal and Southern part of Medak districts), Central-Telangana Zone (Medak, Warangal and Khammam) and Northern-Telangana Zone (Adilabad, Karimnagar and Nizamabad). The present study was undertaken for major crops of Rice, Maize and Cotton in 10 districts of Telangana state during 2014.

Analysis

The data required for the study based on annual rainfall for district wise over a period of 30 years (1988 to 2017) had been collected from various published sources such as Directorate of Economics and Statistics (Hyderabad), Telangana State Development Planning Society, Hyderabad and Indian Meteorological Department, Pune.

Precipitation Concentration Index (Oliver, 1980) reveals the range of concentration of rainfall *i.e.,* uniform to very high, even or uneven distribution of rainfall in a month which is important for crop growth and significantly influences the crop productivity.

$$\text{PCI seasonal} = \frac{\sum Pi^2 \times 100}{(\sum Pi)^2}$$

Pi = Monthly precipitation of any month, i

According to Oliver (1980), precipitation values can be interpreted as follows.

<10 - Uniform monthly distribution of rainfall (low precipitation concentration)

11 to 15 - Moderate precipitation distribution

16 to 20 - High precipitation distribution

>21 - Very high precipitation distribution

Correlation analysis was carried out to find out the relationship between the precipitation concentration index and crop yields of rice, maize and cotton. As per the crop growth season, PCI was worked out for the south-west monsoon for the past 30 years (1988-2017).

RESULTS AND DISCUSSIONS

Mean rainfall was found to be highest in Adilabad district with an average of 1179.1 mm. While Rangareddy received minimum average rainfall *i.e* 774.5 mm during the last thirty years indicating its vulnerability.

District-wise PCI was calculated for south-west monsoon over the past 30 years (1988-2017) to know the fluctuation in distribution of rainfall over a period of time. The value ranged from 10 to 21 which revealed that the precipitation was concentrated in few months of the year which indicates varying distribution of rainfall. From the Table-1, uniform distribution of precipitation *i.e* low PCI (<10) was not noted in past thirty years. Moderate PCI (11-15) was noted in all the districts for 22 years of Rangareddy, 19 years of Khammam, Mahabubnagar and Warangal, 16 years of Khammam and Nalgonda, 10 years of Adilabad, Medak and Nizamabad respectively. Similarly, high PCI had occurred in 19 years of Nizamabad, 18 years of Adilabad, 17 years of Medak, 12 years of Karimnagar, 11 years of Nalgonda, 10 years of Khammam. Adilabad, Karimnagar, Mahabubnagar and Nalgonda had received very high PCI in two years, Medak in 3 years and Warangal in one year. However, usage of water conservation through proper rain water harvesting structures like farm ponds may be developed for effective use of rain water to avoid rainfall fluctuations. In Telangana, watershed programmes may be strengthened to enhance the water table and conservation of soil moisture. Further, more exploratory studies probing into the impact PCI on crop performance have to be initiated. District wise trends in PCI was shown in figure 2.

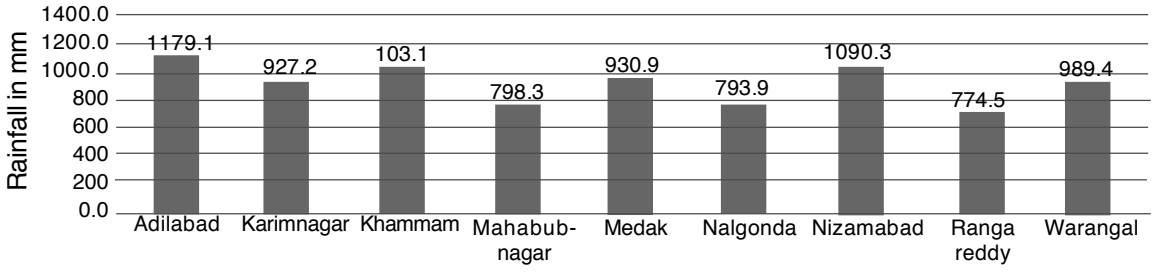
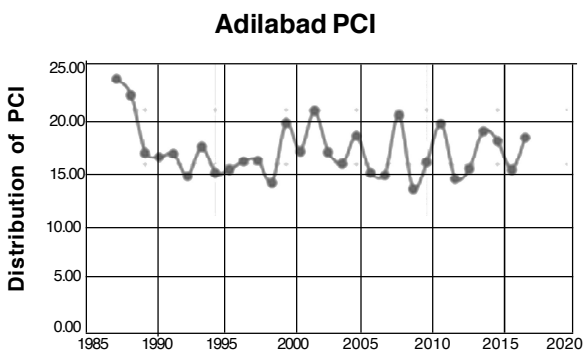
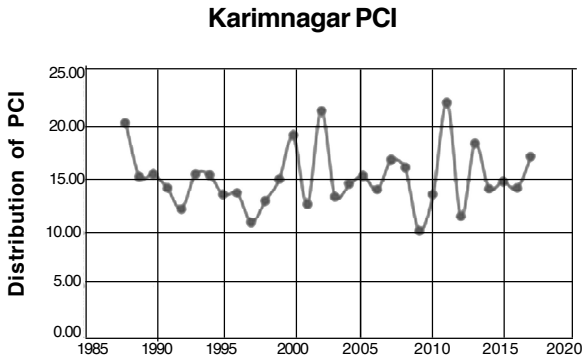


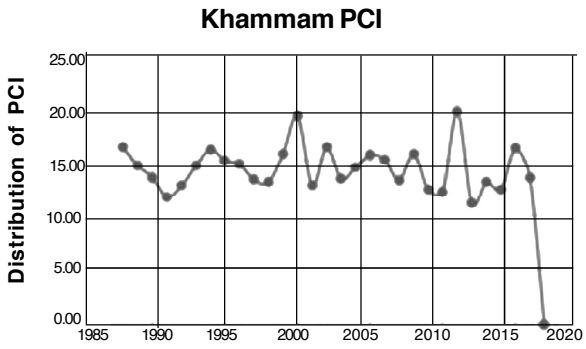
Fig 1. Mean Annual Rainfall in different districts of Telangana (1988-2017)

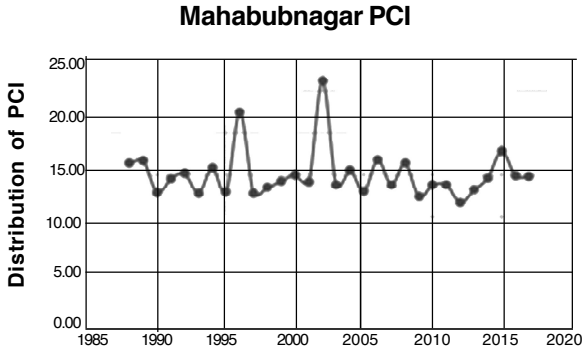
Table1. District-Wise Precipitation Concentration Index during south-west monsoon season (1988-2017)

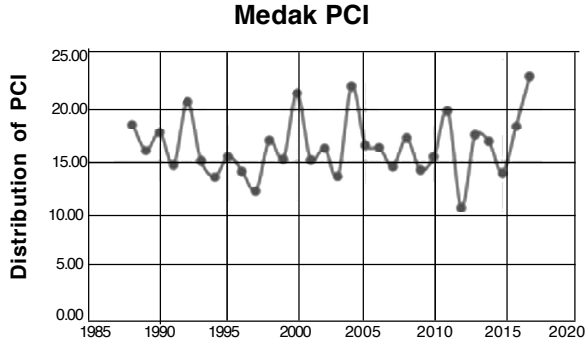
Precipitation Concentration Index	Adilabad	Karim nagar	Khammam	Mahabub nagar	Medak	Nalgonda	Nizamabad	Rangareddy	Warangal
< 10	0	0	1	0	0	1	1	2	1
11-15	10	16	19	19	10	16	10	22	19
16-20	18	12	10	9	17	11	19	6	4
>21	2	2	0	2	3	2	0	0	6

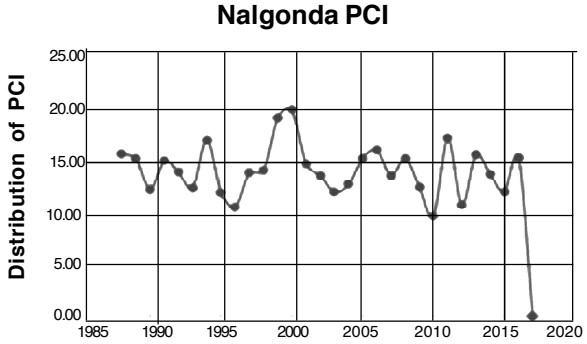












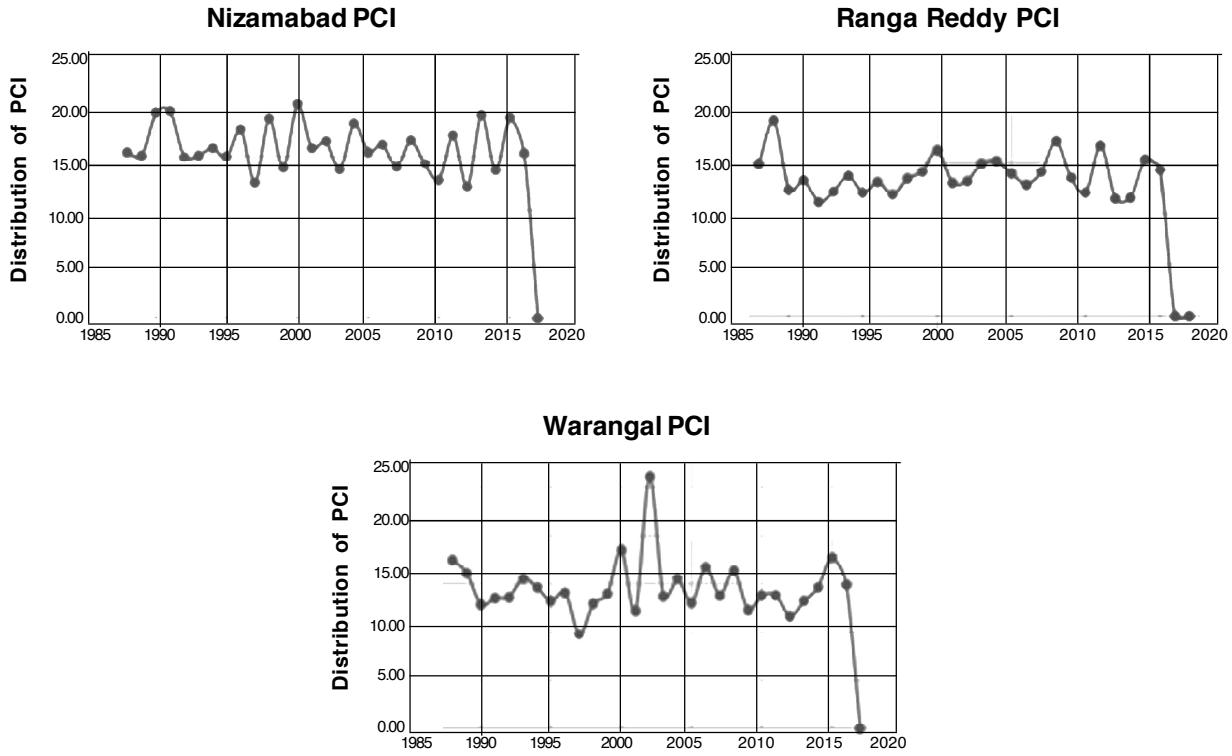


Figure 2. Trends in precipitation concentration index at district level over the past 30 years

To analyse the impact of PCI and yields of major crops rice, maize and cotton, correlation coefficient worked out to know the relationship between the crop yields and precipitation over the past 30 years (1988-2017). Since the crop growth periods were tone with rains received from south-west monsoon (1988-2017) therefore the PCI was calculated for the south-west monsoon period.

Rice yields showed negative correlation with PCI in all the districts except Karimnagar, Mahabubnagar and Medak. Rokonuzzaman *et al*, (2018) reported that more precipitation in the years of lowest rice production period, heavy precipitation responsible for yield reduction.

Maize yields showed negative correlation with PCI in all the districts except Karimnagar, Medak and Nalgonda districts. The PCI had its impact on irrigated, dry and rainfed crops like maize and cotton than rice as it was evident by the negative correlation coefficient values. Xiang *et al,* (2014) observed an increase in precipitation during climate sensitive periods of maize production can increase the soil moisture and mitigate the negative effects of the increased temperature on maize plants at Northeast and Southwest China.

Cotton yields were found to be significant but negatively correlated in Khammam, Mahabubnagar, Nizamabad, Rangageddy and Warangal districts while positively correlated in Medak district. Negative correlation between PCI and cotton yields implied that as PCI values increased cotton yields were reduced. Gwimbi and Mundoga (2010) measured impact of

Table 2. District wise correlation between the precipitation concentration index and crop yields over last 30 years

District	Rice	Maize	Cotton
Adilabad	-0.187	-0.209	-0.057
Karimnagar	0.017	0.189	-0.022
Khammam	-0.278	-0.119	-0.630 ***
Mahabubnagar	0.075	-0.028	0.034 ***
Medak	0.172	0.055	0.718 ***
Nalgonda	-0.263	0.218	-0.623 ***
Nizamabad	-0.299	-0.231	-0.742 ***
Rangareddy	-0.242	-0.228	-0.486 ***
Warangal	-0.223	-0.135	-0.648 ***

*** Significant at 1% level

climate change for the entire growing season of cotton and found that declined cotton production levels as precipitation decreased and temperature increased.

CONCLUSION

It can be concluded that the relationship between precipitation concentration and yields of rice and maize found to be non-significant while cotton found to be significant in Khammam, Nalgonda, Nizamabad, Rangareddy and Warangal districts. The impact of climate change is visible as distribution of rainfall measured in terms of precipitation is irregular and therefore more explorative studies are needed to study alternative measures to handle excessive rains by rain harvesting and moisture stress during the long dry spells.

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Research Article
The J. Res. PJTSAU 49 (1&2) 43-48, 2021

AN ECONOMIC ANALYSIS OF CULTIVATION OF POPULAR PJTSAU RICE VARIETY, RNR 15048 (TELANGANA SONA) *VIS-A-VIS* OTHER RICE VARIETIES

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Date of Receipt : 10-02-2021 Date of Acceptance : 03-04-2021

ABSTRACT

Rice continues to be the staple food of people in many parts of India. Investing on the research in rice crop will help in nourishing maximum population is not only the country but also in the Asian Continent. Under the umbrella of National Agricultural Research System (NARS) and Indian Council of Agricultural Research (ICAR), all the State Agricultural Universities (SAU) have been under the mission of developing technologies catering the regional and national needs. Professor Jayashankar Telangana State Agricultural University (PJTSAU) works with the same mission of developing many technologies and varieties. RNR 15048 (Telangana Sona) is one such variety which is popular not only in the state but also in the country for its super fine quality and its low glycemic index which is good for diabetic patients. The present study was carried out in Wanaparthy district of Telangana covering a sample of 120 farmers to make a comparison of the economics of the RNR 15048 cultivation with the other super fine varieties grown in the same region during the year 2018-19. Conventional tabular analysis was adopted to compare the costs and returns of RNR 15048 variety with the other rice varieties grown in the study area. RNR 15048 was found better than its counterparts since it is cost effective than the other varieties because of its comparative low plant protection cost. RNR 15048 fetched a net income of about Rs.45005.27when compared to Rs.37617.99 per hectare of other varieties. The return per rupee spent on RNR 15048 worked out to be 1.53 as against 1.43 on other varieties. Consumers were also showing high preference for RNR 15048 because of its suitability for diabetic consumers. Hence, the research investment on RNR 15048 was found to be fruitful and the university may continue its seed production and distribution.

Food is the most basic requirement for sustaining every kind of living creature on this earth. Green revolution played an important role in reaching self-sufficiency in food production in India. The most important feature of Green revolution which led to the significant gain in momentum in the production of food grains was the development of High Yielding Varieties (HYV). The development of such High Yielding Varieties will reap its maximum benefit only when it reaches the targeted group efficiently. The National Agricultural Research System (NARS) of India is one of the largest in the world, investing about 0.3% of agricultural Gross Domestic Product (GDP) (Mruthyunjaya and Ranjitha, 2008). It is the job of the researchers to ensure the fruitfulness of the crop varieties developed for the benefit of the farming community. Adoption of the improved crop varieties in a sustainable manner would certainly help in improving livelihood of rural farmers (Asfaw *et al*., 2012).

Rice (*Oryza sativa*) is the most important food crop in the world, directly feeding more people than any other crop. India's rice production has risen from 69.35 million tonnes in the year 2005-06 to 102.19 in 2018-19 and registering a CAGR (Compound Annual Growth Rate) of 3.03 percent during 2005-06 and 2018-19 (DES, 2019). India was the largest exporter of rice in 2017-18 followed by Thailand, Vietnam and Pakistan (DAC & FW, 2019).

All State Agricultural Universities (SAUs) are on the path of developing varieties suitable for their respective state conditions and macro-environment. Since inception of the university, many research works are being carried out in the state and after bifurcation in 2014, the Professor Jayashankar Telangana State Agricultural University (PJTSAU) as a separate entity has been indulged in rigorous research works in crop improvement constantly to cater the needs of farming community of the state. Rice is the single largest crop that occupied more than one-third of cultivated area in the state and area under the crop has increased remarkably during the last agricultural year. In 2020, Telangana farmers were advised by the Telangana Government to grow paddy on 40 lakh acres, including fine varieties, on 25 lakh acres through its agricultural

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strategy of regulated farming directing the farmers in the state to cultivate designated crops to meet the type and extent of demand for commodities in the market.

Varietal development is not an easy task since it utilizes lot of men, material, money and time. Such tedious and resource consuming process will achieve its real purpose only when it meets the need. The variety considered in this study, RNR 15048, was released by PJTSAU in 2015. The variety has been proven to be with low glycemic index of 51.72 ± 3.39 and found significant in reduction of postprandial glucose response in Type 2 diabetes and increase in plasma HDL levels and therefore useful in the management of type 2 diabetes and in the long-term management of cardiovascular diseases (Prasanthi *et al*., 2019). The low glycemic rice has been exported to Kuwait with a first batch of 24 tonnes consignment under the name of Befach Diabetic White rice. (Telangana Today, 2021).

Salient features of Telangana Sona (RNR 15048) reported by University

The variety was reported to be suitable for cultivation in both *kharif* and *rabi* seasons maturing in 125 days. The reported salient features of the variety include

i. Super fine grain (short slender) with high milling recovery (68-70%) and grain yield of 6500 to 7000 Kg/ha.

ii. Saves plant protection cost of about Rs. 2000 to Rs. 3000/acre because of its resistance to Blast and tolerance to Brown Plant Hopper.

iii. Good cooking quality

The present study aimed to work out the comparative economics of cultivation of improved variety RNR 15048 with the other varieties being cultivated in the study area.

MATERIAL AND METHODS

Source of data

The study was conducted in Wanaparthy district which is situated in the Southern region of Telangana. The district was purposively chosen as the highest seed distribution done by state seed department in Wanaparthy district during 2018-19.

The district was carved out of Mahabubnagar, has large rural population and comprises of one revenue division and 14 mandals. River Krishna flows through the district and also has 2301 minor irrigation tanks. The main source of income for this rural population is agriculture and other allied activities like cattle rearing, fishing, poultry, etc. The major crops in the district are rice, cotton, groundnut, maize, red gram and chillies.

Table 1 depicts the particulars of study area and area coverage under the variety RNR 15048 worked out based on seed sales done through the Government departments such as TSSDC (Telangana State Seed Development Corporation) and Agricultural Commissioner Office.

Source: Primary data

The required data on costs and returns of RNR 15048 and other rice varieties were collected from the selected 120 rice farmers through personal interview method with the help of pretested comprehensive interview schedule.The total cost incurred towards

Table 1. Area coverage and number of beneficiaries of the seed distribution of RNR 15048

Name of the variety	RNR 15048
District chosen for the study	Wanaparthy
Area coverage under the variety RNR 15048 based on seed sales (ha) in the district	29049.67
Number of beneficiaries covered under seed distribution in the district	25254
Mandals chosen based on highest area under the variety RNR 15048	Pebbair, Kothakota
Villages selected for the study	Ayyavarapally, Buniadipuram, Burdipalam, Chillumilla, Gummadathandi, Kanchiraopalli, Munagamandhi
Number of sample farmers covered	120

cultivation of RNR 15048 and other rice varieties was worked out as per the cost concepts of Commission for Agricultural Costs and Prices (CACP). The cost of cultivation and farm income were compared for RNR 15048 and other rice varieties grown in the study area using simple tabular analysis.

The various cost concepts worked out include, Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3.

Cost A1: It is calculated by summing the following costs:

a) Value of hired human labour (casual labour)
b) Value of hired and owned machine labour
c) Value of hired and owned bullock power
d) Value of owned and purchased manures
e) Value of purchased fertilizers
f) Value of seed (farm produced and purchased)
g) Value of plant protection chemicals
h) Irrigation charges
i) Interest on working capital
j) Depreciation on farm implements
k) Land revenue
l) Miscellaneous expenses

Cost A2 = Cost A1 + rent paid for leased-in land

Cost B1 = Cost A1 + Imputed interest on value of owned capital assets (excluding land)

Cost B2 = Cost B1 + Imputed rental value of owned land (net of land revenue) + Rent paid for leased-in land

Cost C1 = Cost B1 + Imputed value of family labour

Cost C2 = Cost B2 + Imputed value of family labour

Cost C3 = Cost C2* + 10% of Cost C2* on account of managerial function performed by farmers

Total cost of cultivation

It included operational costs, material costs and fixed costs in rice cultivation. In operational costs, the cost of human labour either owned or hired, bullock labour and machine power were estimated at prevailing rate in the study area during study period. In case of material cost, cost of seed, manures, fertilizers, irrigation charges were calculated at prevailing price at the time of application on per ha basis for farmers.

Fixed costs included rental value of own land, land revenue, depreciation and interest on value of owned fixed capital assets.

Besides cost concepts, farm business analysis was undertaken to test the efficiency of the farm. It includes items like net income, family labour income, farm business income and farm investment income.

The t-test was used to compare the cost components and yield of RNR 15048 and other varieties.

Farm business analysis

Gross returns included total value of main product and total value of by-product of the crop. For calculating the net returns on per ha basis, all the expenses were deducted from gross returns.

Gross income	= Value of total output (main product + by product)
Farm business	= Gross income – Cost A1 or Cost A2 income
Family labour income	= Gross income – Cost B2
Net income	= Gross income – Cost C3
Farm investment income	= Farm business income – Imputed value of family labour.

Return per rupee spent

Nurunnaher *et al*., (2003) stated that the return per rupee spent is the ratio of the present worth of the gross return to the present worth of the gross cost. It refers to the return per monetary unit of cash cost. This ratio is a common technique used to evaluate the profitability of farming in relation to farm management.

Return per rupee spent = Present worth of gross return ÷ Present worth of gross cost

RESULTS AND DISCUSSION

In Table 2, the particulars of all the operational and fixed expenses of the rice cultivation were compared between the RNR 15048 and other varieties grown in the area such as BPT 5204.

Human labour, machine labour and fertilizer costs were the major elements in the total operational cost of cultivation contributing to 51.29 per cent and 49.84

per cent of total cost of cultivation in the case of RNR 15048 and other varieties respectively. This was in accordance with the results of the comparative study conducted by Abhay *et al.* (2017) in Bihar and Punjab which revealed human labour and fertilizer as the most important inputs in paddy cultivation and expenditure on these two inputs accounted for 58.2 per cent of total operational cost. The difference in cost of cultivation is mainly attributed to the higher cost of plant protection incurred towards long adopted BPT 5204 variety which is prone to diseases like blast and smut and thereby leading to reduced yield. The cost components which show major deviation were compared for significance using paired t-test. Seed and machine labour were not taken into account since there was not much difference in costs between the varieties. From Table 3, it can be observed that plant protection cost is the other varieties.

From Table 4, RNR 15048 variety was found to incur lesser cost of cultivation (Rs.85154.07/ha) when compared to other varieties grown in the area (Rs. 87466.49/ha).

Table 2. Comparative economics of RNR 15048 and other rice varieties grown in the study area

S. No.	Particulars	RNR 15048 (Telangana Sona) (Rs./ha)	Other rice varieties like BPT 5204 (Rs./ha)
Operational expenses			
1.	Land Preparation	5896.13(6.92)	5894.92(6.74)
2.	Seed	2159.00(2.54)	2159.00(2.47)
3.	Manures	3497.71(4.10)	3712.63(4.24)
4.	Chemical fertilizers	7236.92(8.50)	7259.32(8.30)
5.	Insecticides and Pesticides	6320.02(7.42)	8284.63(9.47)
6.	Machine labour	15394.07(18.08)	15261.17(17.44)
7.	Human labour	21047.57(24.71)	21081.84(24.10)
8.	Interest on working capital	1999.64(2.35)	2079.27(2.38)
9.	Miscellaneous expenses	1095.12(1.29)	1081.62(1.24)
	Total operational cost	58397.23(75.91)	60532.13(76.39)
Fixed cost			
1.	Rental value of own land	16322.62(19.17)	16383.00(18.73)
2.	Land revenue	67.58(0.079)	103.89(0.12)
3.	Depreciation	2447.10(2.87)	2494.10(2.85)
4.	Interest on fixed capital	1675.18(1.98)	1667.93(1.90)
	Total fixed cost	20512.48(24.09)	20648.92(23.61)
	Total cost	85154.07	87466.49

Note: Figures in parentheses indicate percentage to the total

Source: Primary data

Table 3. Comparison of cost components and yield of RNR 15048 and other varieties

Variables (Telangana Sona)	RNR 15048 like BPT 5204	Other rice varieties	t-test
Fertilizer (₹ /ha)	7236.92	7259.32	0.25
Plant protection chemicals (₹ /ha)	6320.02	8284.63	5.41 **
Human labour (₹ /ha)	21047.6	21081.8	1.24
Yield (q/ha)	62.38	62.50	0.17

**- Significant at 1% level of significance ($p<0.01$)

Source: Primary data

Table 4. Cost of cultivation of rice as per cost concepts (Rupees per hectare)

S.No.	Particulars	RNR 15048 (Telangana Sona)	Other rice varieties like BPT 5204
1.	Cost A1	62004.03	64214.91
2.	Cost B1	63679.20	65882.84
3.	Cost B2	80001.20	82265.84
4.	Cost C1	68832.07	71083.45
5.	Cost C2	85154.07	87466.49
6.	Cost C3	93669.48	96213.14

Source: Primary data

Table 5. Farm business analysis of RNR 15048 and other rice varieties grown in the study area

S.No.	Particulars	RNR 15048 (Telangana Sona)	Other rice varieties like BPT 5204
1.	Total cost of cultivation (₹ /ha)	85154.07	87466.49
2.	Yield (q/ha)	62.38	62.50
3.	Market price (₹ /q)	2016.39	1932.67
4.	Gross return (₹ /ha)	130159.34	125084.48
5.	Farm business income (₹ /ha)	68155.31	60869.57
6.	Family labour income (₹ /ha)	50158.14	42818.64
7.	Net income (₹ /ha)	45005.27	37617.99
8.	Farm investment income (₹ /ha)	63002.44	55668.92
9.	Return per rupee spent	1.53	1.43

Source: Primary data

Table 5 depicted that net returns of the farmers cultivating RNR 15048 variety (₹ 45005.27/ha) was found to be 22.86 per cent higher than the farmers cultivating other varieties (₹ 37617.99).

Though the yield of RNR 15048 and other varieties seems to be equal, the yield of BPT 5204 was comparatively better than others. In contrast, family labour income, farm business income and farm investment income were found to be higher for Telangana Sona when compared to the other varieties grown in the study area. It has also been found that even though the other varieties are equally profitable as RNR 15048, the latter is found to have higher BC Ratio of 1.53 when compared to 1.43 for the other varieties.

Hence, RNR 15048 was found better economically in comparison to the other varieties grown in the area. Thus, the research investment on RNR 15048 is found to be fruitful and the university may intensify its seed production and distribution.

CONCLUSION

The economic impact and added benefit of the variety RNR 15048 over the other varieties will justify the adoption by the farmers. The PJTSAU variety RNR 15048, which is highly adopted in Wanaparthy district of Telangana State was found to have comparatively high net return and lesser cost of cultivation. Hence, the extension personnel may focus on wider dispersion of the variety to farmers for better benefit of farming

community. The researchers may also focus on intensifying the seed production and development of rice varieties with similar traits. The appealing nature of RNR 15048 implies that it is important to take the consumer preference also into account for the variety to have good marketing thereby allowing wider adaptability by farmers.

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Research Article
The J. Res. PJTSAU 49 (1&2) 49-52, 2021

EFFECT OF DIETARY SUPPLEMENTATION OF PROBIOTICS ON INTERNAL AND EXTERNAL EGG QUALITY OF WHITE LEGHORN LAYERS

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Date of Receipt : 04-02-2021 Date of Acceptance : 23-03-2021

ABSTRACT

The objective of the present study was to assess the three different types of multi strain probiotics (100 & 200 g/ton) in comparison to antibiotic (bacitracin methylene disalicylate) on performance of layers. For this purpose, 288 White Leghorn layers were distributed randomly in to 8 different treatments with 6 replicates having 6 birds/replicate. The production performance was evaluated from 22 to 37 week of age. The Basal Diet (T1, Control) consisted of corn and soybean meal. In the remaining experimental diets Basal Diet + 4×10^9 cfu/g of probiotic -1, (T2); Basal Diet + 8×10^9 cfu/g of probiotic - 1, (T3); Basal Diet + 4×10^9 cfu/g of probiotic - 2, (T4); Basal Diet + 8×10^9 cfu/g of probiotic - 2, (T5); Basal Diet + 4×10^9 cfu/g of probiotic - 3, (T6); Basal Diet + 8×10^9 cfu/g of probiotic 3, (T7); Basal Diet + 50 g/ton AGP (BMD) (T8) in diet. The results revealed that internal and external egg quality parameters of Haugh unit, yolk index, shell thickness, shell percentage and shell strength were significantly ($P<0.05$) influenced by supplementation of probiotics and BMD at different graded levels. Whereas albumen index, shell weight and density were not influenced by all the dietary supplementation groups. From the present study, it can be concluded that multi strain probiotics can be safely used as an alternative to antibiotic (BMD) in commercial layers.

The use of sub-therapeutic levels of antibiotic as routine feed additive has been banned in many countries because of public concern, over possible antibiotic residual effects and the development of drug resistant bacteria. This has led to the development and application of many non-antibiotic substances (probiotic and prebiotic) as performance enhancers. Probiotic is live microbial feed supplement, which beneficially affects the host by improving its intestinal microbial balance. Gut microbiota stimulates the mucosal immune system, help to maintain intestinal homeostasis, and play an important role in digestion and absorption of nutrients (Awad *et al.* 2006). Probiotic compete with pathogenic bacteria for binding sites and nutrients, thus supporting a healthy gut microbial ecosystem (Mizak *et al.* 2012). Hence, the present study was designed to explore the influence of dietary supplementation of different multi strain probiotics on internal and external egg quality of layer chicken.

MATERIAL AND METHODS

The experiment was carried out during 2019-20 by two hundred and eighty-eight (288) White Leghorn layers (BV 300) were distributed randomly in to 8 different treatments with 6 replicates having 6 birds/replicate. Prior to experiment, the pre layer ration was fed to the birds till 21 weeks and layer ration from 22 weeks onwards (ME 2620 kcal/kg and CP 16.97%). The Basal Diet (T1, Control) diet consisted of corn and soybean meal. In the remaining experimental diets Basal Diet + 4×10^9 cfu/g of probiotic - 1 containing (*Bacillus subtilis, Bacillus coagulants* and *Sacchromyces boulardii*), (T2); Basal Diet + 8×10^9 cfu/g of probiotic - 1 (T3); Basal Diet + 4×10^9 cfu/g of probiotic - 2 containing (*Bacillus subtilis, Sacchromyces boulardii* and *Clostridium butryicum*) (T4); Basal Diet + 8×10^9 cfu/g of probiotic - 2 (T5); Basal Diet + 4×10^9 cfu/g of probiotic - 3 containing (*Bacillus sps Lactobacillus sps, Enterococcus sps, pediococcus acidilactici, sacchromyces boulardii* and *Clostridium butryicum*) (T6); Basal Diet + 8×10^9 cfu/g of probiotic - 3 (T7); Basal Diet + 50 g/ton AGP (BMD) (T8) in diet and evaluated for production performance. The internal and external egg quality were studied for a total of four laying periods of 28 days each from 22 to 37 week of age. The data was analyzed by SPSS (20.0).

RESULTS AND DISCUSSION

Internal egg quality parameters

Haugh unit (HU) was significantly ($P<0.05$) influenced by supplementation with probiotics and BMD at graded levels during 22-37 weeks (Table 1). The

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results were in accordance with the findings of Zhang *et al*. (2012) and Sobczak *et al*. (2015). In Contrary, Panda *et al*. (2006), Berrin (2011) and Fathi *et al*. (2018) reported no significant difference in Haugh unit with probiotic supplementation. There was no significant difference in albumen index but supplementation of probiotic at different graded levels was comparable with control during 22-37 weeks. But, a significant (P<0.05) difference in yolk index among different levels of probiotic fed groups were observed (Table 1). These findings were in accordance with Yalcin *et al*. (2008).

External Egg Quality Parameters

Supplementation of different multistrain probiotics did not influence on egg shell weight during 22-37 weeks. Similar findings were reported by Forte *et al*. (2016). Whereas in contrary to the above results, significant (P<0.05) difference in shell weight among the treatment groups was reported by Panda *et al*. (2006) and Fathi *et al*. (2018).

Shell thickness during the overall period showed a significant (P<0.05) difference among the treatments which were in agreement with Zhang *et al*. (2012) and Sobczak *et al*. (2015). In Contrary, Yalcin *et al*. (2008) did not observe any significant difference with probiotic in layers birds. This beneficial effect may be attributed to a favourable environment in the gastrointestinal tract resulting from the administration of probiotic to birds. Probiotic bacteria increase the rate of fermentation and the production of short-chain fatty acids (SCFAs), which reduces the luminal pH. Low luminal pH increases calcium solubility and absorption. SCFAs stimulate intestinal epithelial cell proliferation and villus height, which increases absorption efficiency (Van *et al*. 1999). As a result, more nutrients, including calcium, can be assimilated, thus improving eggshell quality.

Supplementation of probiotics significantly (P<0.05) improved the shell percentage during 22-37 weeks. The findings of the present study are in agreement with those of Mikulski *et al*. (2012). But, Forte *et al*. (2016) reported contrary results to the present findings. Also, the shell strength was significant (P<0.05) in supplementation with probiotics and BMD at different graded levels in overall period, but significantly (P<0.05) higher value was observed in control group (21.15 N) compared with treatment groups. The above results are in agreement with the findings of Upadhaya *et al*. (2016) and Fathi *et al*. (2018) who reported a significant (P<0.05) improvement in shell strength in White Leghorn layers. Shell breaking strength was significantly higher in the probiotic-fed groups. This could be attributed to the higher shell thickness, which might have created greater resistance resulting in higher breaking strength. Contrary to the

Table 1. Effect of dietary supplementation of probiotic at graded levels on internal egg quality parameters in White Leghorn layers during 22-37 weeks of age

Treatment	g/ton	Haugh unit	Albumen index	Yolk index
Control	0	85.46 ^{cd}	0.082	0.462 ^{b}
Probiotic -1	100	86.80 ^{b}	0.080	0.465 ^{ab}
Probiotic -1	200	87.68 ^{a}	0.080	0.467 ^{ab}
Probiotic -2	100	85.53 ^{cd}	0.082	0.473 ^{a}
Probiotic -2	200	84.95 ^{d}	0.080	0.463 ^{b}
Probiotic -3	100	85.01 ^{d}	0.082	0.473 ^{a}
Probiotic -3	200	86.12 ^{bc}	0.082	0.473 ^{a}
BMD	50	86.31 ^{b}	0.085	0.465 ^{ab}
N		6	6	6
P-Value		0.001	0.251	0.043
SEM		0.149	0.001	0.001

Means with different superscripts in a column differ significantly (P<0.05),
BMD= Bacitracin methylene disalicylate

Table 2. Effect of dietary supplementation of probiotic at graded levels on external egg quality parameters in White Leghorn layers during 22-37 weeks of age

Treatment	g/ton	Egg shell weight (g)	Egg shell thickness (mm)	Egg shell percentage (%)	Egg shell strength (N*)	Density (g/cm3)
Control	0	5.712	0.404 ^{bc}	10.02 ^{a}	21.15 ^{a}	1.090
Probiotic -1	100	5.692	0.397 ^{d}	9.658 ^{b}	18.71 ^{e}	1.087
Probiotic -1	200	5.589	0.401 ^{bc}	9.623 ^{b}	19.81 ^{cd}	1.087
Probiotic -2	100	5.631	0.404 ^{bc}	9.775 ^{ab}	20.91 ^{a}	1.086
Probiotic -2	200	5.626	0.399 ^{cd}	9.680 ^{b}	19.30 ^{de}	1.085
Probiotic -3	100	5.581	0.405 ^{a}	9.638 ^{b}	20.06 ^{bc}	1.085
Probiotic -3	200	5.652	0.406 ^{a}	9.732 ^{b}	20.63 ^{ab}	1.086
BMD	50	5.668	0.404 ^{bc}	9.818 ^{ab}	20.92 ^{a}	1.087
N		6	6	6	6	6
P-Value		0.804	0.001	0.019	0.001	0.180
SEM		0.022	0.001	0.035	0.140	0.001

Means with different superscripts in a column differ significantly (P<0.05),
BMD= Bacitracin methylene disalicylate

findings of the present study, Shalaei *et al.* (2014) did not observe any difference in the Shell strength. However, the density (g/cm^3) of egg was non-significant in all the treatment groups during over all period (Table 2).

CONCLUSION

It could be concluded that supplementation of different multi strain probiotics improved the both internal & external egg quality parameters compared to control and can be safely used as an alternative to antibiotic (BMD) in commercial White Leghorn layers.

ACKNOWLEDGEMENT

The authors are thankful to Sanzyme Biologics Private Limited, Hyderabad for funding the research.

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Research Article
The J. Res. PJTSAU 49 (1&2) 53-59, 2021

EFFECT OF SUPPLEMENTATION OF DETOXIFIED KARANJ CAKE ON CARCASS CHARACTERISTICS, IMMUNE RESPONSE AND BIOCHEMICAL PROFILE OF BROILER CHICKEN

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Date of Receipt : 03-04-2021 Date of Acceptance : 03-06-2021

ABSTRACT

An experiment was conducted to evaluate the effect of solvent extracted karanj cake (SKC), SKC treated with 2% NaOH, 1% NaOH + 1% HCl treated SKC and 3% iso propyl alcohol (IPA) treated SKC on carcass, humoral immune response and biochemical changes in broiler chickens. The experiment comprising of 13 dietary treatments, T1 as control (without karanj cake). SKC diets at 3, 6 and 9% levels were designated as T2, T3 and T4; NaOH treated SKC at 3, 6 and 9% levels were designated as T5, T6 and T7; NaOH + HCl treated SKC at 3, 6 and 9% levels were designated as T8, T9 and T10; while T11, T12 and T13 comprised of 3%, 6% and 9% IPA treated SKC diets respectively. Six replicates were allocated to each treatment, employing five birds/replicate. The experimental period was from day old to 42 d of age. The results revealed that dietary inclusion of either SKC or processed SKC significantly ($P<0.05$) increased the liver weight, gizzard and giblet weight compared to control group at 42 d of age. The relative weight of pancreas, abdominal fat, kidney and ready to cook yield were not affected by the dietary inclusion of either SKC or processed SKC. No significant difference was recorded in haemagglutination inhibition (HI) titers to sheep red blood cells (SRBC), cell mediated immune response to phytohaemagglutin-P (PHA-P) and relative weights of spleen and bursa at 42 d of age. The serum protein levels significantly ($P<0.05$) increased in IPA treated SKC, NaOH treated SKC and SKC at 6% compared with control. Significantly ($P<0.05$) lower serum cholesterol level was observed in groups fed 3 & 6% alkali treated SKC compared to control diet. Processing of SKC did not influence the activity of Alkaline phosphatase (ALP) at 3rd and 6th week of age. Finally, it was concluded that NaOH, NaOH + HCl and IPA treated SKC (3, 6 and 9%) could be safely included in commercial broilers diet without any adverse effects.

The large gap between the availability and requirements of poultry feeds necessitated the exploration of alternate unconventional feeds in poultry rations. Karanj seeds are mainly used for oil extraction and the residue left after oil extraction is known as karanj cake. Two types of the cakes are available depending upon the type of extraction, namely expeller pressed and solvent extracted cake, which have good amount of protein used for animal feeding. The CP content of the cake is fairly rich and it generally varies from 22.0 to 28.7 and 30.0 to 38.0% in expeller and solvent extracted cakes, respectively (Paswan *et al*., 2020; Raj *et al*., 2016). However, raw karanj cake is not commonly used as a feed for poultry due to presence of toxic factors, i.e. total tannins, phytate, karanjin and trypsin inhibitors and furanoflavones like Pongamol, Kanugin and Kanjone compounds. Feeding of karanj cake at higher levels adversely affected the performance due to the presence of toxic factors in the oil or oil fraction of the cake (Natanam *et al.,* 1989a; Dhara *et al.,* 1997). Detoxification of karnaj cake with chemicals partially alleviated growth depression in broiler chicken (Panda, 2004).

Various treatments such as autoclaving, water washing, soaking, partial deoiling and alkali treatments have been tried to detoxify the karanj cake. However, none of these treatments appeared to make the processed cake completely safe, suitable and wholesome for animal feeding. Consequently, further efforts need to be made to evolve suitable method(s) of detoxification in order to convert karanj cake into a wholesome protein supplement, which would be used for poultry feeding. Keeping this background in view, the present study was carried out aiming at exploring and developing some novel methods for detoxification of solvent extracted karanj cake by removal of various toxins present in it, so that it can be safely used as poultry feed.

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MATERIAL AND METHODS

A growth trial was conducted with commercial broilers (*Cobb* 400), to evaluate the feasibility of using four types of processed karanj cakes, Solvent extracted karanj cake (SKC), Sodium hydroxide (2% NaOH) treated SKC, 1% NaOH & 1% HCl (Hydro chloric acid) treated SKC and 3% Iso propyl alcohol (IPA) treated SKC in broiler pre starter (0-11days), starter (12-21days) and finisher (22-42days) rations at 3 graded levels (3, 6 and 9%) against a control diet. A total of 390-day-old commercial broiler (*Cobb* 400) chicks were procured, wing banded and weighed individually. The experiment comprising of 13 dietary treatments, T1 as control, SKC diets at 3, 6 and 9% levels were designated as T2, T3 and T4; NaOH treated SKC at 3, 6 and 9% levels were designated as T5, T6 and T7; NaOH + HCl treated SKC at 3, 6 and 9% levels were designated as T8, T9 and T10; while T11, T12 and T13 comprised of 3%, 6% and 9% IPA treated SKC diets respectively. Six replicates were allocated to each treatment, employing five birds/replicate. The experimental period was from day old to 42 d of age. At the end of experiment (42nd day), one representative bird from each replicate of a dietary treatment was slaughtered through cervical dislocation after fasting for ten hours with free access to water. The ready to cook yield and weight of giblet (liver, heart and gizzard), pancreas, abdominal fat, kidney and lymphoid organs (thymus, spleen and bursa of fabricus) were recorded at the end of experiment (42nd day). Immune response of broiler chicks was studied by measuring CMI to PHA-P and HI titers to sheep red blood cells (SRBC) at 6th week of age. At 42nd days, blood was collected from two birds from each replicate and analyzed for protein and cholesterol concentration and activity of alkaline phosphatase.

Data analyzed for mean, standard errors and analysis of variance as per method of Snedecor and Cochran (1989) and comparison of means were done using Duncan test (1955) using software of Statistical Package for Social Sciences (SPSS) 20.0 version and significance was considered at $P<0.05$.

RESULTS AND DISCUSSION

Carcass Characteristics

The liver, gizzard and giblet weights were significantly ($P<0.05$) higher in the birds fed with SKC, NaOH treated SKC, NaOH + HCl treated SKC and IPA treated SKC than control diet at 42 days of age. But, Ready to Cook Yield (RCY), percent weight of pancreas, abdominal fat and kidney were comparable among all the dietary groups to that of control (Table 1). This might be due to higher digestibility and lower levels of toxins in NaOH, NaOH + HCl & IPA treated SKC. Concomitant to the findings of the present study, Panda *et al*., (2007) reported that liver, gizzard and giblet weight increased in 50% level of SKC. The percent weights of heart and abdominal fat were similar in all the dietary groups. Similarly, Mandal and Banerjee (1982a) did not observe any difference in the weights of liver, heart and kidney with 6% deoiled karanj cake. Inclusion of karanj cake at 10% resulted in a significant change in the weight of liver and pancreas was reported by Natanam *et al.,* (1989b). However, Dhara *et al.,* (1997) did not find any significant ($P>0.05$) variation in weight of liver, heart and gizzard due to inclusion of deoiled karanj cake.

Immune Parameters

The relative weight of spleen and bursa, haemagglutination inhibition (HI) titers to sheep red blood cells (SRBC), cell mediated immune response to phytohaemagglutin –P (thickness index) were not influenced significantly ($P>0.05$) at 42 days of age. Whereas, thymus weight was significantly ($P<0.05$) higher in the chicks fed with SKC or processed SKC compared with control diet (Table 2).

The increased thymus weight might be due to improved feed intake, better nutrient digestibility of nutrients in processed karanj cake. The improved protein digestibility increased the thymus weight in turns increased antibody production enhanced macrophage activity and increased local antibodies (IgA) at mucosal surfaces. The weight of spleen, thymus and bursa is directly proportional to immune response in broilers. The higher lymphoid organs weight also supports the increased immune response in test groups. The results observed in the present study agree with the reports of Panda *et al.,* (2004), who reported that the percent live weight of spleen, bursa and thymus were similar in SKC, 1.5% NaOH treated SKC, 3% Ca $(OH)_2$ treated SKC and 2% NaOH treated karanj cake dietary groups at 6 weeks of age. Similar results were also reported by Mandal and Banerjee (1982a), Panda *et al*., (2007) and Krishnamoorthy *et al*., (2013). Humoral and cell mediated immune response depends on several factors such as dosage of antigen, type of

Table 1. Effect of dietary inclusion of detoxified *Karanj* cake at graded levels on carcass variables and organ weights (% live weight) at 42 days of age

Trt code	Karanj cake		*RCY	Liver	Gizzard	Giblet	Pancreas	Abdominal fat	Kidney
	Type	% in diet							
T_1	Control (without karanj cake)	-	67.870	1.856 ^{f}	1.698 ^{d}	4.001 ^{f}	0.204	1.519	0.522
T_2	SKC	3	66.740	2.286 ^{de}	1.920 ^{bcd}	4.643 ^{de}	0.246	1.350	0.593
T_3	SKC	6	67.770	2.450 ^{cde}	2.055 ^{abc}	4.970 ^{cde}	0.259	1.797	0.577
T_4	SKC	9	65.670	2.879 ^{a}	2.319 ^{a}	5.678 ^{a}	0.251	1.014	0.589
T_5	NaOH treated SKC	3	67.970	2.174 ^{e}	2.022 ^{abcd}	4.678 ^{de}	0.220	1.765	0.496
T_6	NaOH treated SKC	6	65.370	2.459 ^{bcde}	1.968 ^{abcd}	4.845 ^{de}	0.214	1.583	0.533
T_7	NaOH treated SKC	9	67.070	2.762 ^{ab}	2.243 ^{abc}	5.427 ^{abc}	0.257	1.101	0.621
T_8	NaOH & HCl treated SKC	3	68.130	2.207 ^{e}	1.895 ^{cd}	4.523 ^{e}	0.237	1.953	0.513
T_9	NaOH & HCl treated SKC	6	68.240	2.573 ^{abcd}	2.057 ^{abc}	5.031 ^{cd}	0.249	1.327	0.596
T_{10}	NaOH & HCl treated SKC	9	66.890	2.728 ^{abc}	2.267 ^{ab}	5.506 ^{ab}	0.234	1.411	0.575
T_{11}	IPA treated SKC	3	67.340	2.236 ^{de}	2.142 ^{abc}	4.859 ^{de}	0.284	1.416	0.490
T_{12}	IPA treated SKC	6	66.530	2.249 ^{de}	2.166 ^{abc}	4.845 ^{de}	0.275	1.522	0.601
T_{13}	IPA treated SKC	9	68.860	2.393 ^{cde}	2.219 ^{abc}	5.049 ^{bcd}	0.288	1.373	0.576
	N		6.000	6.000	6.000	6.000	6.000	6.000	6.000
	P value		0.751	0.001	0.006	0.0001	0.186	0.224	0.641
	SEM		0.332	0.042	0.034	0.0625	0.006	0.065	0.013

Means bearing at least one common superscript in a column do not differ significantly (P<0.05)

***Ready to cook yield; SKC – Solvent extracted karanj cake; IPA – Isopropyl alcohol**

Table 2. Effect of *Karanj* cake on Immune organs and Immune response of broiler chicken at 42 days of age

Trt code	Karanj cake		Thymus	Relative weight (g /100g)		SRBC titers (log2)	*PHA-P response (thickness index)
	Type	% in diet		Spleen	Bursa		
T_1	Control (without karanj cake)	-	0.295 ^{bcd}	0.101	0.144	2.670	140.500
T_2	SKC	3	0.221 ^{d}	0.141	0.139	3.170	153.900
T_3	SKC	6	0.343 ^{abc}	0.149	0.235	2.830	159.400
T_4	SKC	9	0.256 ^{cd}	0.101	0.169	4.000	164.000
T_5	NaOH treated SKC	3	0.317 ^{bcd}	0.093	0.191	3.500	180.400
T_6	NaOH treated SKC	6	0.330 ^{bcd}	0.127	0.174	2.500	167.800
T_7	NaOH treated SKC	9	0.340 ^{abc}	0.142	0.166	3.330	161.400
T_8	NaOH & HCl treated SKC	3	0.301 ^{bcd}	0.150	0.162	4.000	169.400
T_9	NaOH & HCl treated SKC	6	0.366 ^{abc}	0.145	0.172	3.830	169.200
T_{10}	NaOH & HCl treated SKC	9	0.326 ^{bcd}	0.135	0.196	4.170	153.100
T_{11}	IPA treated SKC	3	0.409 ^{ab}	0.143	0.289	3.170	155.700
T_{12}	IPA treated SKC	6	0.447 ^{a}	0.154	0.179	2.670	159.700
T_{13}	IPA treated SKC	9	0.297 ^{bcd}	0.134	0.203	2.830	175.100
	N		6.000	6.000	6.000	6.000	6.000
	P value		0.005	0.191	0.122	0.869	0.644
	SEM		0.011	0.005	0.009	0.206	3.131

Means bearing at least one common superscripts in a column do not differ significantly (P<0.05)

Table 3. Effect of dietary inclusion of detoxified *Karanj* cake at graded level on serum biochemical profile in broiler chicken at 3rd and 6th week of age

Trt code	Karanj cake		Protein (g/100ml)		Cholesterol (mg/100ml)		Alkaline Phosphatase (µl/lit.)	
	Type	% in diet	3rd week	6th week	3rd week	6th week	3rd week	6th week
T_1	Control (without karanj cake)	-	2.910 ^{ab}	2.223	69.49 ^{d}	51.71 ^{cd}	577.8	140.3
T_2	SKC	3	2.834 ^{ab}	2.644	85.16 ^{cd}	51.89 ^{cd}	147.1	134.6
T_3	SKC	6	3.018 ^{ab}	2.169	87.83 ^{cd}	59.63 ^{cd}	253.3	142.2
T_4	SKC	9	1.758 ^{b}	2.625	152.54 ^{ab}	52.81 ^{cd}	191.6	112.2
T_5	NaOH treated SKC	3	1.758 ^{b}	2.119	176.23 ^{a}	43.69 ^{d}	159.1	91.1
T_6	NaOH treated SKC	6	3.594 ^{ab}	2.464	125.26 ^{bc}	39.45 ^{d}	297.5	76.6
T_7	NaOH treated SKC	9	2.765 ^{ab}	2.204	92.90 ^{cd}	57.97 ^{cd}	256.3	58.3
T_8	NaOH & HCl treated SKC	3	2.761 ^{ab}	2.160	97.05 ^{cd}	98.90 ^{b}	208.8	19.6
T_9	NaOH & HCl treated SKC	6	1.761 ^{b}	2.315	104.4 ^{cd}	89.03 ^{bc}	263.3	26.6
T_{10}	NaOH & HCl treated SKC	9	2.182 ^{b}	2.001	124.9 ^{bc}	141.1 ^{a}	226.8	32.9
T_{11}	IPA treated SKC	3	2.483 ^{b}	2.964	120.3 ^{bc}	67.01 ^{bcd}	224.6	37.8
T_{12}	IPA treated SKC	6	4.497 ^{a}	2.860	105.6 ^{cd}	87.10 ^{bc}	201.8	66.7
T_{13}	IPA treated SKC	9	2.945 ^{ab}	2.524	128.3 ^{bc}	82.49 ^{bc}	295.9	36.3
	N		0.050	0.34	0.001	0.001	0.9	0.1
	P value		6.000	6.000	6.000	6.000	6.0	6.0
	SEM		0.167	0.079	4.889	4.312	26.0	10.1

Means bearing at least one common superscripts in a column do not differ significantly (P<0.05).

antigen, route of administration and sensitivity of an individual (Gross and Siegel, 1993). Since all the factors were kept constant in the present study, the variation might be due to presence of toxins in the karanj cake.

Serum Biochemical Profile:

Among all the treatment groups, significantly ($P<0.05$) increased serum protein levels was observed in IPA treated SKC at 6% at 3 weeks of age. While, the protein concentration among other treatment groups were comparable. However, no significant ($P>0.05$) difference was observed in protein levels of different treatments at 6 weeks of age (Table 3).

Among all the treatment groups, significantly ($P<0.05$) lower serum cholesterol levels were observed in control group and SKC (3, 6 & 9) treated groups at 3 weeks of age. However, 3, 6 and 9% alkali treated SKC groups recorded the lower cholesterol levels compared to other treatment groups at 6 weeks of age. The ALP activity in the serum was higher in the control group compared with groups fed the karanj cake diets. Processing of SKC did not influence the activity of ALP at 3rd and 6th week of age (Table 3). Reddy *et al.,* (2011) reported decreased total protein level and increased total cholesterol levels in SKC fed group, which was attributed to liver insufficiency and hepatotoxic action of karanjin. Panda (2004) reported reduced serum protein concentration when NaOH (1.5%) treated SKC was used beyond 12.5%. Panda *et al.,* (2007) recorded significant reduction in the activity of ALP when alkali treated SKC was supplemented with methionine, similar to the levels observed in the control diet.

CONCLUSION

Supplementation of NaOH, NaOH+HCl and IPA treated solvent extracted karanj cake (3, 6 and 9%) did not showed any adverse effect on carcass, immunity and serum parameters of broilers. Thus, it may be concluded that NaOH, NaOH+HCl and IPA treated SKC can be safely included as an alternative protein source in commercial broilers.

ACKNOWLEDGEMENT

The authors are thankful to Department of Poultry Science, College of Veterinary Science, Rajendranagar, Hyderabad, and Department of Science & Technology, Ministry of Science and Technology, Govt. of India for funding the research work and to M/S Rohini Biotech, Hyderabad for supplying the karanj seeds used for the study.

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Research Note
The J. Res. PJTSAU 49 (1&2) 60-64, 2021

ECONOMICS OF GERBERA UNDER POLYHOUSE CULTIVATION IN RANGA REDDY DISTRICT OF TELANGANA STATE

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Date of Receipt : 06-05-2021 Date of Acceptance : 30-06-2021

India has been predominantly an agrarian country where majority of farmers use traditional farming techniques. Traditional farming has always been risky due to unpredictable weather conditions and exposure to pests and diseases. Moreover, in recent years' climate change has become biggest challenge. To meet the food requirements of growing population, crops have to be cultivated under protected conditions without depending upon the external climatic conditions. Thus, protected cultivation assumed lot of significance in recent years.

In order to bring larger areas under protected cultivation the Government of India initiated a number of schemes such as National Horticultural Mission (NHM), Horticulture Mission for North East and Himalayan (HMNEH) and Rashtriya Krishi Vikas Yojana (RKVY) for promotion and development of protected cultivation of horticultural sector.

Keeping in view the importance of protected cultivation the Government of Telangana has introduced the polyhouse scheme and considered the establishment of polyhouse as a flagship programme. The scheme was implemented in 2014-15 with 75 per cent subsidy under Normal State Plan scheme in the entire state for cultivation of vegetables and flowers.

To study the economics of Gerbera cultivation under polyhouse and also to examine the economic feasibility of investment under polyhouses, the present study was undertaken in Ranga Reddy district. Ranga Reddy district was purposively selected as the district is having highest area under polyhouse cultivation. Three Mandals namely Chevella, Moinabad and Shamshabad were selected based on the highest area under polyhouse cultivation. Six villages were from Chevella Mandal, four Villages were from Moinabad and three villages from Shamshabad Mandal were selected based on the highest area under poly houses. Fifty farmers having an area of 2000-4000 Sq.m under polyhouses were selected randomly from these selected villages.

The required primary data was obtained through a pretested schedule through interview method. The collected data was analysed through simple tabular analysis and various project appraisal techniques such as Pay Back Period, Benefit Cost Ratio, Net Present Value and Internal Rate of Return.

1. Investment costs of selected polyhouses units

The investment under polyhouse cultivation is classified into establishment costs and annual maintenance costs.

A. Establishment costs

The establishment costs comprised of structure cost and land preparation costs. The details of these costs are furnished in Table 1(a).

The structure costs include costs incurred on polyhouse structure frame, drip unit, foggers, motor and sprayer. These costs are one-time investment cost for entire life period (10 years) of the structure. The government provides subsidy to the structural frame work to an extent of 50 to 60 per cent. From the Table.1(a), It is observed that structure costs for polyhouse units (2004 m^2) worked out to be Rs. 9,43,930.00. These costs accounted for 60.50 per cent of total establishment costs.

Among the structure costs, the cost of structure frame for polyhouse units was Rs. 7,60,000.00 which accounted for more than 80 per cent of the total structure cost, followed by drip and foggers (16.10 %), Motor (2.00 %) and sprayer (1.40 %).

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The land preparation costs include costs incurred on labour, soil, manures, chemicals for soil drenching and planting material. The planting material of Gerbera can be used for period of five years and needs to be replaced after 5 years. The government provides subsidy to the planting material to an extent of 50 per cent. The details of land preparation costs for poly house units are presented in Table 1(a). The land preparation costs worked out to be Rs. 6,16,939.70 which accounted for 39.50 per cent of total establishment cost.

Among the land preparation cost of poly house units, the cost of soil accounted for major share (34.70 %), followed by planting material (31.30 %), manures (17.00%), labour (12.70 %) and chemicals for drenching (4.30 %).

B. Annual Maintenance costs

The annual maintenance costs are the costs incurred for performing the various operations every year. The annual maintenance costs include costs of human labour, fertilizers, pesticides, transportation and packing. The details of annual maintenance costs for polyhouse units (2004 m^2) are presented in Table 1(b). From the Table, it is observed that the annual maintenance costs of poly house units worked out to be Rs.7,61,490.00.

Among the annual maintenance costs, fertilizer costs accounted for major share of 29.50 per cent. This is followed by the cost incurred on pesticides (26.22 %), packing and packaging (23.11 %), human labour (16.13 %) and transportation costs (5.04 %).

Table 1(a): Establishment costs of selected polyhouse units

S.No.	Particulars	Cost / 2004 m^2 (Rs)	
A	**Structure costs (For 10 years)**		
1	Polyhouse structure frame (Including polythene sheet)	7,60,000.00	(80.50)
2	Drip and foggers	1,52,400.00	(16.10)
3	Motor	18,500.00	(2.00)
4	Sprayer	13,030.00	(1.40)
	Total Structure costs (A)	**9,43,930.00**	(100) (60.50)
B	**Land preparation costs (For 5 years)**		
1	Labour costs	78,460.00	(12.70)
2	Soil	2,13,942.00	(34.70)
3	Manures	1,04,963.00	(17.00)
4	Chemicals for soil drenching	26,567.20	(4.30)
5	Planting Material	1,93,007.50	(31.30)
	Land preparation costs (B)	**6,16,939.70**	(100) (39.50)
	Total establishment costs (A+B)	**15,60,869.70**	(100)

Figures in single parenthesis indicate percentage to respective totals
Figures in double parenthesis indicate percentage to total establishment costs

Table 1(b): Annual maintenance costs of selected polyhouse units

S.No.	Particulars	Cost / 2004 m^2 (Rs)	
1	Human Labour (Inter cultivation, showering,harvesting and others.)	1,22,844.40	(16.13)
2	Fertilizers	2,24,640.00	(29.50)
3	Pesticides	1,99,680.00	(26.22)
4	Transportation	38,346.00	(5.04)
5	Packing & packaging	1,75,980.00	(23.11)
	Total Annual maintenance costs	**7,61,490.00**	**(100)**
	Total costs (cash out flow)	**23,22,359.70**	

Figures in parenthesis indicate the percentages to total

The sum of structure cost, land preparation and annual maintenance costs becomes the cash out flow for the first year and for the subsequent year's annual maintenance costs along with the interest were considered as out flow.

2. Cost of cultivation of Gerbera under selected polyhouse units

Gerbera is an important cut flower, native to tropical Asia and Africa. Success of Gerbera under protected conditions has encouraged farmers to take up its protected cultivation extensively during the past few years in India. It is one among the top ten earners of the world in cut flower trade. Most of the polyhouse farmers in the study area cultivate Gerbera as the major crop under polyhouses.

The cost and returns of Gerbera under selected polyhouse units (2004 m^2) for one year were worked and results presented in Table 2. The average cost of cultivation of Gerbera under polyhouse unit worked out to be Rs.10,32,518.40. Out of which Variable costs were Rs. 8,65,826.00 accounting for maximum share of 83.90 percent. While fixed costs were Rs. 1,66,692.40 which accounted for 16.10 per cent of total costs.

Out of the variable costs the expenditure on fertilizers accounted for maximum share of Rs. 2,24,640.00 (21.80 %), followed by Rs. 1,99,680.00 (19.30 %) for pesticides, packing (17.00 %), labour (13.40 %), planting material (3.70 %), transportation (3.70 %), soil (2.10%), Interest on working capital (1.35%), manures (0.1 %) and machine power (0.15%).

Out of the fixed costs depreciation accounted for maximum share of Rs. 94,393.00 (9.10 %), followed by interest on fixed capital (6.00 %) and rental value of owned land (0.1%).

3. Returns from Gerbera cultivation under selected polyhouse units

Returns from Gerbera cultivation under poly house units were worked and furnished in Table 3. From the Table, it is observed that the average yield under poly house units was 62,764.80 bunches. The average price per bunch worked out to be Rs. 22.5. Gross returns and net returns were Rs. 14,12,208.00 and Rs. 1,98,995.60 respectively.

Table 2: Cost of cultivation of Gerbera under selected poly house units

S.No.	Particulars	Cost / 2004 m^2 (Rs)
I	**Variable costs**	
1	Human labour	1,38,536.40 (13.40)
2	Machine power	1,598.40 (0.15)
3	Soil	21,394.20 (2.10)
4	Planting material	38,601.50 (3.70)
5	Pesticides	1,99,680.00 (19.30)
6	Manures	10,496.30 (1.00)
7	Fertilizers	2,24,640.00 (21.80)
8	Chemicals for soil drenching	2,656.70 (0.30)
9	Transportation	38,346.00 (3.70)
10	Packing	1,75,980.00 (17.00)
11	Interest on working capital@12%	13,896.50 (1.35)
	Subtotal of variable costs (I)	**8,65,826.00 (83.90)**
II	**Fixed costs**	
1	Depreciation	94,393.00 (9.10)
2	Interest on fixed capital @12%	62,299.40 (6.00)
3	Rental value of owned land	10,000.00(0.10)
4	Rent paid for leased in land	0.00
	Subtotal of fixed costs (II)	**1,66,692.40 (16.10)**
	Total cost of cultivation (I + II)	**10,32,518.40 (100)**

Figures in parenthesis indicate the percentages to total

Table 3. Returns from Gerbera cultivation under selected poly houses (Rs / 2004 m²)

S. No.	Particulars	
1	Average Yield (Bunches)	62,764.80
2	Average Price / bunch	22.50.00
3	Gross returns (Rs)	14,12,208.00
4	Net returns: Gross Returns-Cost C3 (Rs)	1,98,995.60

4. Economic viability of selected polyhouse units

Cash out flow comprises all the cash that goes out of the farm business which includes structure costs, land preparation costs, annual maintenance costs, fixed costs, variable costs, etc. Cash inflows include all the cash that comes in to the farm business from sale of the produce. The cash flows were projected for a period of 10 years as the average life span of polyhouse structure was assumed to be 10 years. The life span of its poly cover and the planting material was assumed to be 5 years and they need to be replaced after 5 years of establishment.

The sum of structure cost, land preparation and annual maintenance costs were considered as the cash out flow for the first year. For the subsequent years' annual maintenance costs along with the interest were considered as cash out flow.

The costs and returns were calculated for the first year and for the remaining nine years they were assumed to inflate at the rate of 2 per cent per annum.

The economic viability of selected polyhouse units was assessed by using project appraisal techniques for both situations namely with and without subsidy. Discount rate of 12 per cent was used to work out Pay Back Period, Net Present Value, Benefit Cost Ratio and Internal Rate of Return. The present analysis was carried with subsidy and without subsidy for polyhouse farmers. The details were presented in the Table 4.

From the Table, it is observed that Pay Back Period for selected polyhouse units was 2.89 years with subsidy and it was 8.02 years without subsidy. Benefit Cost Ratio was worked out to be 1.22 with subsidy and 1.05 without subsidy. Net Present Value was Rs. 17.45 lakhs with subsidy and Rs. 4.57 lakhs without subsidy and Internal Rate of Return was 56 per cent with subsidy against 18 per cent without subsidy.

From the results it can be inferred that investment in polyhouse cultivation is more economically viable when the farmers get subsidy from the government.

CONCLUSION

Thus, the study concludes that cultivation of Gerbera under polyhouse is highly capital intensive. But cultivation of Gerbera under selected polyhouse units was found to be economically viable as indicated by Benefit Cost Ratio of 1.22, Net Present Value of 17.45 lakhs and IRR of 56 per cent, when farmers were provided with subsidy, compared to without subsidy. Hence the farmers can be encouraged to bring more area under poly house cultivation provided, if the Government provides subsidy to an extent of 75 per cent, keeping in view the changes in climatic conditions.

Table 4. Economic viability of selected polyhouse units (2004 m²)

S. No	Particulars	Unit	With subsidy	With-out subsidy
1	Pay Back Period (PBP)	Years	2.89	8.02
2	Benefit Cost Ratio (BCR)	-	1.22	1.05
3	Net Present Value (NPV)	Lakh Rs	17.45	4.57
4	Internal Rate of Return (IRR)	Per cent	56.00	18.00

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Research Note
The J. Res. PJTSAU 49 (1&2) 65-68, 2021

THE UTILIZATION PATTERN OF *RYTHU BANDHU* SCHEME (RBS) - A CASE STUDY IN NALGONDA DISTRICT OF TELANGANA

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Date of Receipt : 15-02-2021 Date of Acceptance : 03-04-2021

Agriculture is an important sector of Indian economy contributing 16 percent of overall GDP with 44 percent of the population getting employment from it still today. Since independence, Indian government has taken several initiatives to improve agriculture starting with first ever land reforms, development of irrigation projects then after green revolution, subsidies, liberalization and many loan waiving schemes which served the development of agriculture to certain level but the contribution of agriculture sector to GDP has decreased from 1950's to 2015 leading to agrarian crisis. Agriculture now became no longer a profitable economy as the increased cost of cultivation did not keep pace with returns leading to indebtedness among farmers.

To overcome all these, Telangana government has come with an innovative scheme on direct investment support to the farmers through cash transfer, which is locally called as *Rythu Bandhu* Scheme (RBS) on 25 February 2018, aimed at providing direct investment support in the form of cash per year per season to all land owning farmers other than tenant farmers. In 2018-19, state budget, ₹ 12,000 crore was allocated under this scheme to provide @ Rs. 4000/ per year/per farmer to all land holders.

This scheme is expected to benefit the land owning farmers in the form of a) reduce the farmers dependency on private borrowings with the availability of liquid cash being provided under RBS b) to facilitate the purchase of farm inputs c) to reduce overall financial burden of the farmers on their own financial resources. Further the RBS is also expected to contribute to meet household expenditure on non- agriculture needs.

As this scheme is implementing since 2018-19 *Kharif*, it is worthwhile to evaluate the utilization of RBS money by beneficiaries to check whether the usage could meet the expectation of Government. For this, a sample of 120 farmers from 4 villages of Nalgonda district were selected by Multi-stage sampling procedure. The details of utilization of *Rabi* 2018-19 and *Kharif* 2019-20 RBS money were collected from sample farmers as field survey was conducted for this season only. The utilization was classified into agricultural usage and non-agricultural usage.

Agricultural usage

The usage for inputs purchases like seeds, fertilizers, pesticides etc. and labour wages were considered under agricultural usage.

Non-Agricultural usage

The usage for children education and health costs, to clear previous debt, consumption needs, liquor expenses etc were considered as non-agricultural usage. The above classification is in conformity with the Ali *et al.* (2011) where they classified loan utilization for two purposes *viz.*, productive purpose includes agriculture, animal husbandry and cottage industry and consumptive purpose includes domestic, social, educational and health.

1. Utilization pattern of RBS amount received by farmers during *Rabi* 2018-19 and *Kharif* 2019-20.

The RBS amount received by beneficiary along with the percentage utilized for agriculture and non-agriculture purpose during *Rabi* 2018-19 and *Kharif* 2019-20 was averaged according to farm size and presented in table 1.

The average amount received by all beneficiary farmers increased from Rs. 20004 in *Rabi*

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2018-19 to Rs. 25074 in *Kharif* 2019-20. This increase is primarily due to enhancement of RBS support from ₹ 4000 to ₹ 5000 per acre per season. Similarly, the percentage utilized for agriculture purpose increased from *Rabi* 2018-19 to *Kharif* 2019-20 from 68% to 71.5% of RBS amount by all farmers. This is because of increase in costs of inputs and labour wages which led to increase in cost of cultivation and certainly utilization towards agriculture purpose increased in *Kharif* 2019-20. These results are similar to Jaulkar *et al.* (2001) where they found 51 percent of agricultural loan of RRB was utilized fully while 23 percent partially and 26 percent not utilized for specific purpose and Harikumar (1991) who studied the utilization and repayment of agricultural loans of Regional Rural Banks in Kozikode district and revealed that 51 percent utilized loan fully, 23 percent partially and 26 percent not utilized for specific purpose.

In comparison of utilization of RBS among three farm groups, the large farmers used 75 percent of *Rabi* amount and 83 percent of *Kharif* amount for agriculture purpose which is high among all category farmers during two seasons. This is because of their strong financial status and the amount received by them was high certainly used for particular operation at a stretch. But it follows decreasing order as medium farmers utilized only 71 percent in *Rabi* and 74 percent in *Kharif* was used for agriculture purpose with rest of amount diverted to non-agriculture purposes. Similarly small farmers utilized only 68 percent in *Kharif* and very less only 65 percent in *Rabi* for agricultural purpose indicating rural distress among small farmers and the amount provided was liquid cash directly credited into bank account which can be used for other purposes according to their need and there was no monitoring of its usage. These results are in contrast with Grover *et al.* (2018) who studied the utilization pattern of input subsidies in Punjab agriculture and found access to credit and subsidies improved with increase in farm size and education.

1. 1. Share of amount utilized among input use and labour use under agriculture purpose by beneficiary farmers during *Rabi* 2018-19 and *Kharif* 2019-20.

From the Table 2, it is observed that among agricultural purpose on an average 71% during *Rabi* and 65% during *Kharif* was used for input purchase by all farmers together. Most of the farmers reported that RBS amount was paid to input dealers soon after received. However, among large farmers the share of input cost and labour cost is almost same *viz.*, 53% and 47% respectively of agriculture purpose in *Rabi* 2018-19.

Table 1. Utilization pattern of amount received by farmers of different farm size groups under *Rythu Bandhu* Scheme, during *Rabi* 2018-19 and *Kharif* 2019-20.

Season	Type of farmer	Average amount received by beneficiary farmer (Rs.)	Percentage utilized for (percent)	
			Ag. Purpose	Non-Ag.Purpose
Rabi 2018-19 (n=95)	Small farmer (n=53)	13543.4	65.0	35.0
	Medium farmer (n=34)	24782.0	71.0	29.0
	Large farmer (n=8)	42500.0	75.0	25.0
	Pooled (n=95)	20004.0	68.0	32.0
Kharif 2019-20 (n=74)	Small farmer (n=41)	16762.2	68.0	32.0
	Medium farmer (n=26)	30894.0	74.0	26.0
	Large farmer (n=7)	52143.0	83.0	17.0
	Pooled (n=74)	25074.0	71.5	28.5

Source: Primary data collected from sample farmers.

Table 2. Share of amount utilized among input use and labour use under agriculture purpose by beneficiary farmers during *Rabi* 2018-19 and *Kharif* 2019-20.

Season	Type of farmer	Average amount spent for Agriculture purpose by beneficiary farmer (Rs.)	Percentage utilized for (%)	
			Input purpose	Labour Purpose
***Rabi* 2018-19**	Small farmer (n=53)	8825	63	37
	Medium farmer (n=34)	17525	77	23
	Large farmer (n=8)	31750	53	47
	Pooled (n=95)	13869	71	29
***Kharif* 2019-20**	Small farmer (n=41)	11362	62	38
	Medium farmer (n=26)	22740	62	38
	Large farmer (n=7)	42500	86	14
	Pooled (n=74)	18305	65	35

Source: Primary data collected from sample farmers.

1. 2. Share of amount utilized for various non-agriculture purposes during *Rabi* 2018-19 and *Kharif* 2019-20.

The percentage of RBS money used for different non-agricultural purposes during two seasons is presented in Table 3. It is observed that among small farmers and medium farmers, large portion of non-agriculture utilised money of RBS was spent on clearing pervious debts. Further sizeable part of RBS amount was also spent on other purposes such as consumption needs, children education and liquor consumption *etc.* Further, among large farmers children's education and consumption needs contributed equally and together contributed almost half of the non-agriculture use *viz*., 26% and 27% respectively followed by debts in *Rabi*. However, in *Kharif*, children education alone contributed nearly half of the non-agriculture use *viz.,* 42.5% followed by health costs, debts, consumption needs and liquor expenses among large farmers. The results obtained are in compliance with the Singh *et al.* (2008) where consumption needs, repayment of old debts, relending, ceremonies and functions etc. are the factors underlining diversion of credit.

The primary reason for using RBS amount for children's education during *Kharif* was the beginning of schools/colleges in the month of June/July which is coinciding with *Kharif*. The financial pressure on farm families is more during these months on account of children's education cost. Therefore, sizeable part of RBS amount was spent on children's education by the sample farmers.

Table 3. Share of amount utilized for various non-agriculture purposes during *Rabi* 2018-19 and *Kharif* 2019-20.

Season	Type of farmer	Average amount used for Non-agriculture purpose (₹)	Percentage utilized for (%)				
			Consum-ption needs	To clear debts	Children Education	Health costs	Liquor expen-ses
***Rabi* 2018-19**	Small farmer (n=53)	4718.4	29	44	11	13	3
	Medium farmer (n=34)	7257	25	34	18	18	5
	Large farmer (n=8)	10750	27	23	26	14	10
	Pooled(n=95)	6135	27	39	15	15	4
***Kharif* 2019-20**	Small farmer (n=41)	5400	25	30	34	9	2
	Medium farmer (n=26)	8154	16	32	34	14	4
	Large farmer (n=7)	9643	14	15.5	42.5	19	9
	Pooled(n=74)	6769	21	29	35	12	3

Source: Primary data collected from sample farmers.

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The J. Res. PJTSAU 49 (1&2) 69-74, 2021

CONSTRAINTS/CHALLENGES FACED BY FARMERS IN ADOPTION OF MICRO IRRIGATION IN RANGA REDDY DISTRICT OF TELANGANA

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Date of Receipt : 29-04-2021 Date of Acceptance : 09-06-2021

Micro irrigation is a modern method of irrigation; by this method water is irrigated through drippers, sprinklers, foggers and by other emitters on surface and subsurface of land. Water is a relatively scarce resource in India since we have 17 per cent of the world's population and only four per cent of the usable fresh water at global level. Irrigation is the sector that uses water the most. Nearly 80 per cent of the world's water resources are used for irrigation.

To increase area under micro irrigation, Government of India launched the Pradhana Mantri Krushi Sinchayi Yojana (PMKSY) in 2015-16 by combining ongoing schemes. The task force on micro irrigation had estimated a potential of 69.5 million hectares under micro irrigation. Presently, area under micro irrigation in India is 7.73 million hectare in that Drip-3.37 million hectares and Sprinkler-4.36 million hectares (Priyan and Panchal, 2017).

The micro irrigation technology has the potential to double the area under irrigation by judicious utilization of water with efficiency as high as 80 to 90 per cent as compared to 30 to 50 per cent in case of surface irrigation. Micro irrigation systems increasing yield by 30 to 100 per cent, water saving 50 to 70 per cent and fertilizer as well as electricity by 40 per cent because water is directly applied to effective root zone of plants through net work of plastic pipe.

At present, Telangana Micro Irrigation Project, a unique and comprehensive project is being implemented in Telangana state, and area covered under micro irrigation is 7.42 lakh hectares (Micro Irrigation Projects, Telangana state, 2019).

A study on adoption pattern and farmers' behavior towards micro irrigation was conducted in Ranga Reddy district of Telangana state in 2019-20. Ranga Reddy district was selected purposively because it is adjacent to Hyderabad city and farmers in this district are major suppliers of vegetables and flowers to Hyderabad. Two mandals with the highest micro irrigation area was selected and then from each mandal three villages with the highest micro irrigation area was selected. Twenty farmers from each village were selected randomly. Thus, total sample size constitute 120. Survey method was used to collect the required data from the selected respondents with the help of a well-structured, pre-tested questionnaire. The study area was interviewed to know their awareness, adoption pattern, knowledge level, preferences and constraints faced by farmers in adoption of micro irrigation. The study revealed that the farmers' awareness and knowledge level about the micro irrigation technology was high and major problems faced by farmers after micro irrigation system installation were emitters clogging, pipe leakage, pipe blockage, fertigation problem, post installation service by company, motor burning, salt sedimentation on upper layer of soil and improper installation which leads to frequent repair and maintenance. Majority of the farmers faced the "financial constraints" like initial installation cost is more, high cost of maintenance, subsidy provision is less, and loaning procedure is complex and inadequate credit facilities for the farmers.

Constraints/challenges faced by farmers in adoption of micro irrigation in Ranga reddy district of Telangana

The results showed that all the respondents in the sample were aware of micro irrigation systems.

Problems faced by farmers after installation of micro irrigation system

From fig. 1 it can be observed that 42.5 per cent of farmers were not facing any problem whereas, 57.5 per cent of farmers were facing problems after

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installation of micro irrigation. The major problems faced by farmers were emitters clogging, pipe leakage, pipe blockage, fertigation problem, poor post installation service, motor burning, salt sedimentation on upper layer of soil and improper installation which leads to frequent repair and maintenance.

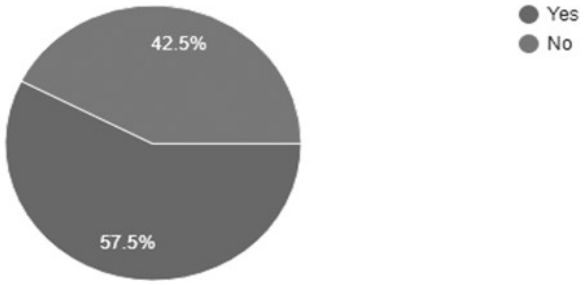

Fig 1. Constraints encountered by farmers at post installation of Micro Irrigation System

Constraints encountered by the farmers in adoption of drip irrigation technology

The constraints encountered by the respondents were categorized into five categories namely technical, infrastructural, financial, educational, climatic and geographical constraints. The constraints have been presented in descending order of the ranks.

A critical examination of data in table 1 reveals that majority of the farmers faced the "financial constraints" (63.9 Mean Score) as initial installation cost is very high, high cost of maintenance, subsidy provision is less, loaning procedure is complex and inadequate credit facilities for the farmers. Due to high cost and complexity of procedures, the respondent might have perceived this category as the most dominant category of constraints in adoption of drip irrigation technology. Hence, it was ranked first. Similarly the "technical constraints" was the second important category of constraints with mean score of 56.04. Other constraints like educational constraints and infrastructural constraints were accorded third and fourth ranks with mean score of 48.08 and 44.91, respectively. The climatic and geographical constraints were the least perceived constraints with the mean score of 39.83.

Hence, it concluded that among all, the financial constraints were the most perceived ones by the farmers and climatic and geographical constraints were observed as the least important.

Rate the constraints faced by framers on micro irrigation system by using five point Likert scale

A Likert Scale is a type of rating scale used to measure attitudes or opinions. With this scale, respondents are asked to rate items on a level of agreement regarding constraints faced. The objective of sub heading is to know the constraints faced by framers on micro irrigation system. It is measured on five point Likert scale having items like Strongly disagree = 1, Disagree = 2, Neutral = 3, Agree = 4 and Strongly agree = 5.

In the below bar graphs X- axis represents five point likerts scale and Y- axis represents number farmers in per cent.

High cost of installation

The below bar graph (Fig. 2) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 51.7 per cent of the farmers "Agreed" that cost of installation for micro irrigation is high. Whereas, 23.3 per cent, 18.3 per cent and 5.0 per cent of farmers "Neutral", "Strongly Agreed", and "Disagreed" that the cost of installation for micro irrigation is high. Further, 1.7 per cent of farmers "Strongly Disagreed" that cost of installation of micro irrigation high. It can be concluded that majority of the farmers (more than 50 per cent) have the opinion that cost of installation of micro irrigation is high.

Table 1. Constraints as encountered by the farmers in adoption of drip irrigation technology

S No.	Particulars	Total score	Mean Score (M.S)	Rank
1	Financial constraints	7669	63.90	I
2	Technical constraints	6725	56.04	II
3	Educational constraints	5770	48.08	III
4	Infrastructural constraints	5390	44.91	IV
5	Climatic and geographical constraints	4780	39.83	V

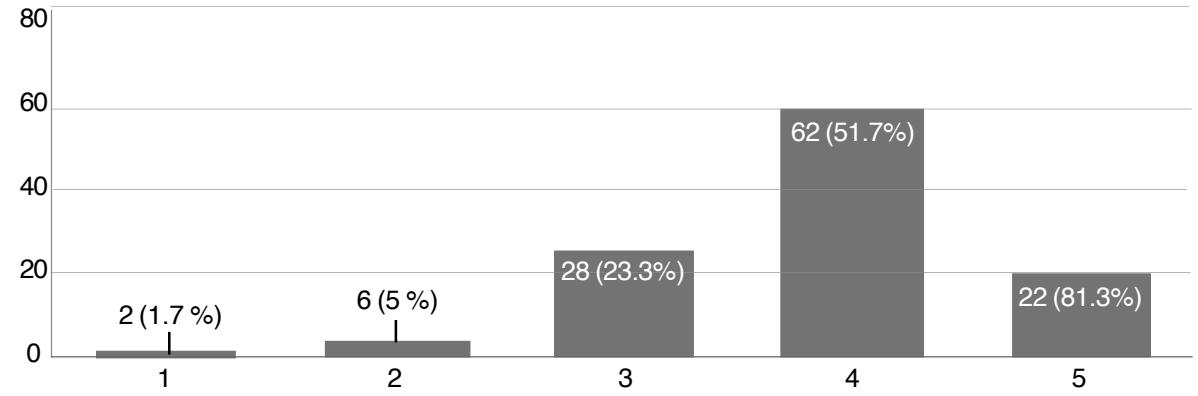

Fig 2. Constraints faced by farmers with reference to cost of installation

Maintenance cost is more

The below bar graph (Fig. 3) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 44.2 per cent of the farmers "Agreed" that cost of repair and maintenance for micro irrigation system is high. Whereas, 25.8 per cent, 19.2 per cent and 6.7 per cent of farmers "Neutral", "Disagreed", and "Strongly Disagreed" respectively that the cost of repair and maintenance for micro irrigation is high. Further, 4.2 per cent of farmers "Strongly Agreed" with the opinion of cost of repair and maintenance for micro irrigation are high. It can be concluded that majority of the farmers (48.4 per cent) have the opinion that cost of maintenance for micro irrigation is high.

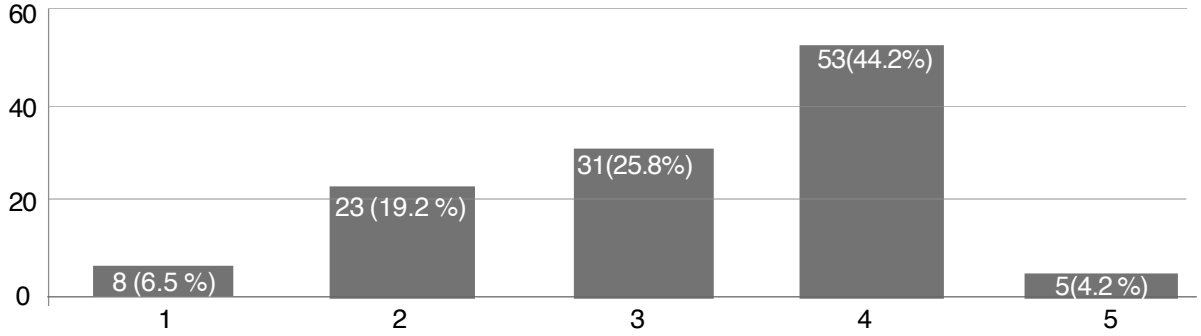

Fig 3. Constraints faced by farmers with respect to Maintenance cost is more

Affects soil quality

The below bar graph (Fig. 4) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 35 per cent of the farmers "Neutral" that usage of micro irrigation system affect soil quality. Whereas, 25.8 per cent, 21.7 per cent and 15 per cent of farmers "Disagreed", "Agreed", and "Strongly Disagreed" respectively that the usage of micro irrigation affect soil quality. Further, 2.5 per cent of farmers "Strongly Agreed" that the usage of micro irrigation affects soil quality. It can be concluded that majority of the farmers (40.8 per cent) have the opinion that usage of micro irrigation affect soil quality

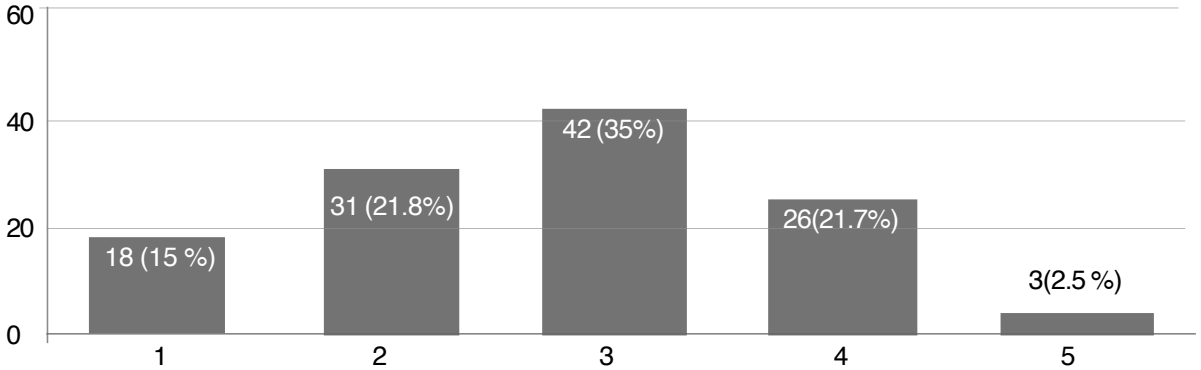

Fig 4. Constraints faced by farmers with reference to affects soil quality

Non availability of parts

The below bar graph (Fig. 5) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 41.7 per cent of the farmers "Agreed" that non availability of micro irrigation system material parts. Whereas, 25.8 per cent, 15.8 per cent and 10.8 per cent of farmers "Neutral", "Disagreed", and "Strongly Agreed" respectively that the non availability of micro irrigation system material parts. Further, 5.8 per cent of farmers "Strongly Disagreed" that the non availability of micro irrigation system material parts. It can be concluded that majority of the farmers (52.5 per cent) have the opinion that non availability of micro irrigation system material parts.

Poor post installation services

The below bar graph (Fig. 6) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 50.8 per cent of the farmers "Strongly Agreed" that poor post installation services of micro irrigation system. Whereas, 39.2 per cent, 4.2 per cent and 3.3 per cent of farmers "Agreed", "Disagreed", and "Neutral" that the poor post installation services of micro irrigation system. Further, 2.5 per cent of farmers "Strongly Disagreed" that poor post installation services of micro irrigation system. It can be concluded that majority of the farmers (90.0 per cent) have the opinion that poor post installation services of micro irrigation system.

Damaged by rodents, animals and fire

The below bar graph (Fig. 7) indicates the constraints faced by farmers on micro irrigation system. Out the total 120 respondent farmers, 40 per cent of the farmers "Agreed" that micro irrigation system damaged by rodents, animals and fire. Whereas, 23.3 per cent, 22.5 per cent and 8.3 per cent of farmers "Strongly Agreed", "Neutral", and "Strongly Disagreed" that the micro irrigation system damaged by rodents, animals and fire. Further, 5.8 per cent of farmers "Disagreed" that the micro irrigation system damaged by rodents, animals and fire. It can be concluded that majority of the farmers (63.3 per cent) have the opinion that micro irrigation system damaged by rodents, animals and fire.

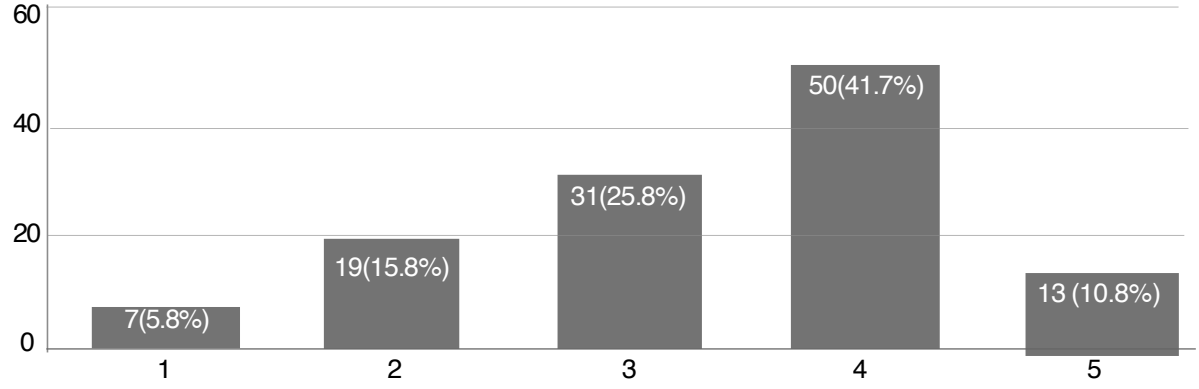

Fig 5. Constraints faced by farmers with respect to Non availability of parts

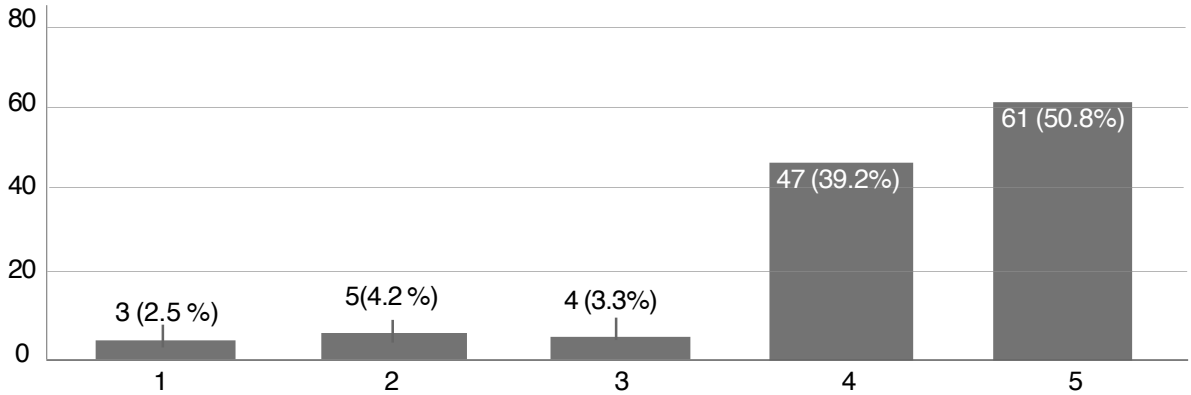

Fig 6. Constraints faced by farmers with reference to Poor post installation services

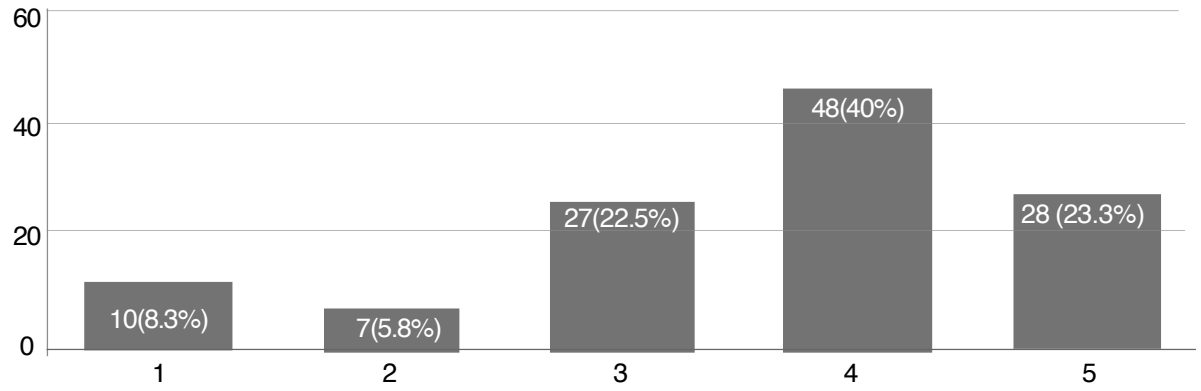

Fig 7. Constraints faced by farmers with respect to Damaged by rodents, animals and fire

Availment of insurance

The below bar graph (Fig. 8) indicates the constraints faced by farmers on micro irrigation system. Out the total 120 respondent farmers, 64.2 per cent of the farmers "Strongly Agreed" that no insurance on micro irrigation system. Whereas, 28.3 per cent and 7.5 per cent of farmers "Agreed" and "Neutral" that no insurance on micro irrigation system. Further, none of the farmer "Disagreed" and "Strongly Disagreed" that no insurance on micro irrigation system. It can be concluded that majority of the farmers (92.5 per cent) have the opinion that no insurance on micro irrigation system.

Clogging problem

The below bar graph (Fig. 9) indicates the constraints faced by farmers on micro irrigation system. Out of the total 120 respondent farmers, 48.3 per cent of the farmers "Agreed" that the more clogging problem in micro irrigation systems. Whereas, 44.2 per cent, 5.8 per cent and 1.7 per cent of farmers "Strongly Agreed", "Neutral" and "Disagreed" that the more clogging problem in micro irrigation systems. Further, none of the farmer "Strongly Disagreed" that more clogging problem in micro irrigation systems. It can be concluded that majority of the farmers (92.5 per cent) have the opinion that the more clogging problem in micro irrigation systems.

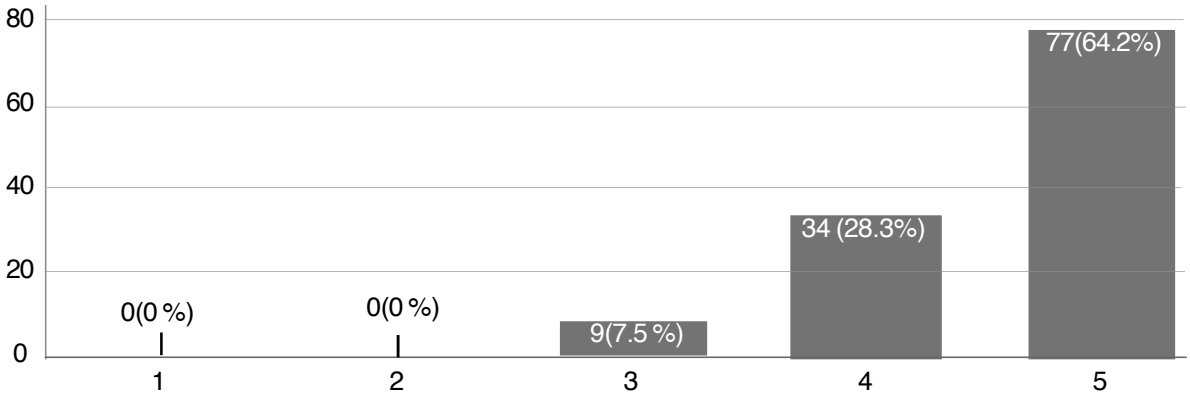

Fig 8. Constraints faced by farmers with reference to Insurance Availment

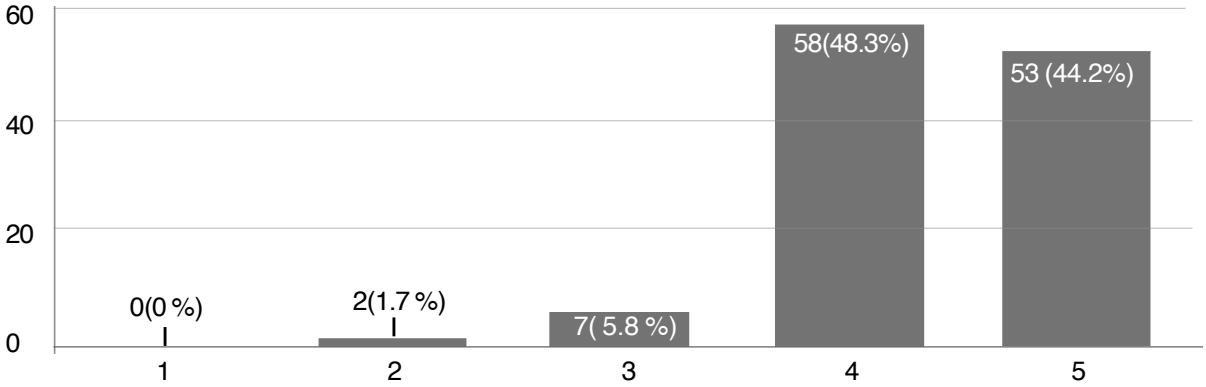

Fig 9. Constraints faced by farmers respect to clogging problem

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Research Note
The J. Res. PJTSAU 49 (1&2) 75-78, 2021

STANDARDISATION AND QUALITY EVALUATION OF MILLET BASED NUTRIBAR

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Date of Receipt : 05-06-2021 Date of Acceptance : 23-06-2021

Millets were indeed one of the oldest foods known to humans but they were discarded in favor of wheat and rice with urbanisation and industrialisation. These grains form a good source of micronutrients, phytochemicals, complement well with lysine-rich vegetable (leguminous) and animal proteins to prepare nutritionally balanced composites of high biological value (Gorinstein *et al*., 2002). The high levels of tryptophan in millet produce serotonin, which is calming to our moods. Magnesium in millet can help reduce the effects of migraines and heart attacks. All millet varieties show high antioxidant activity. Millet is gluten free and non - allergenic. Above all, millet's high protein content makes up for energy deficiency in vegetarian diet.

Compared to the availability of ready-to-eat products from rice, wheat and corn, the products based on millets are still scanty. Millets possess unique nutritional characteristics, specifically, they are gluten-free, represent good source of carbohydrates, rich in dietary fibre, phenolic compounds and also minerals (Saturni *et al*., 2010). The nutrient composition and technological properties of millets offer a number of opportunities for processing and value addition. Research and Development work carried out at CFTRI on processing and value addition of sorghum and millets has indicated the possibility of preparation of a number of new generation products (Meera *et al*. 2008 ; Meera 2009). Among them, puffed products find a potential role in preparation of ready-to-eat foods.

Puffing is one of the easy and economic processing methods to prepare ready-to-eat products. Puffing essentially creates a crisp, aerated product with desirable sensory qualities with low moisture level and hence generally microbially safe. Puffing is not only improves the shelf-life but also improves the nutritional quality with respect to the bioavailability of nutrients.

Nutribars are ready to eat convenient snack foods which provide quality source of nutrients. They are nutritional food with multiple ingredients which are formulated based on the nutritional requirements. According to Trier and Johnston (2012), the sales of nutrition bars have increased almost 10-fold to $1.7 billion over the past decade. Hence, in the present study an attempt has been made to standardise millet based nutribar from sorghum, pearl and finger millet and to evaluate its sensory and nutritional qualities.

In this view, millets like sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum)* and finger millet (*Eleusine coracana)* was used to develop nutribar which were collected from the local market. All other ingredients such as chocolate, cashew nuts, almonds, raisins, jaggery and glucose syrup needed for the study were also purchased from the local market. Prior to the preparation of nutribar, after proper washing, the millets were puffed using a puffing machine and was crushed using a blender into coarse grains. The dry fruits and nuts were also crushed and roasted. The binder syrup was prepared by heating glucose syrup with pre weighed jaggery which was melted by adding 10 ml of water and concentrated to one thread stage. Chocolate was melted using double boiling method and was kept ready for coating the nutribar in a deep bowl.

For the standardisation of millet based nutribar, the millets were used at a level of 20 - 60 per cent in different treatments. Dried fruits like raisins, cashew nuts, almonds were used up to 10 per cent. Jaggery and Glucose syrup were mixed and was used as binder

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syrup. The combinations used are given in Table 1. The experiment was conducted in a Completely Randomised Design (CRD) with 5 treatment combinations and three replications each.

For the preparation of nutribar, the ingredients like millets (puffed and crushed), dried fruits and nuts (roasted) were added one by one to the binder syrup (glucose syrup and jiggery) and mixed well. Later the mixture was transferred to rectangular stainless steel mould and pressed thoroughly with metallic presser. After pressing, it was cut in smaller bars of size 10 cm x 3 cm x 2 cm using bar cutter. On cooling the bars were dipped in melted chocolate and kept in refrigerator for setting and was stored in ambient condition. The weight of each bar was approximately 50g.

For the organoleptic evaluation of the nutribar, the procedure suggested by Jellinek (1985) was followed where a panel of 15 judges evaluated the nutribar using a 9 point hedonic scale. The scores obtained for organoleptic evaluation were evaluated using Kendall's Coefficient of Concordance (W).

The nutritive qualities like moisture (AOAC, 1980), carbohydrate, protein, fat, crude fibre and energy (Sadasivam and Manickam, 1997) of best selected millet based nutribar was determined. Analyses were carried out in triplicate.

The nutribar developed under 5 different trials were evaluated for acceptability through sensory analysis. Sensory evaluation is a scientific method to evoke measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch and taste (Kemp *et al.*, 2009)

The mean scores obtained for the organoleptic qualities of each treatment were statistically analysed using Kendall's coefficient of concordance.

Table 1. Details of combinations of millet based nutribar

Treatments	Millets			Dry fruits	Jaggery	Glucose syrup	Chocolate
	Sorghum	Pearl millet	Finger millet				
T_1	60	-	-	5	10	7	18
T_2	50	5	5	5	10	7	18
T_3	40	10	10	5	10	7	18
T_4	30	15	15	5	10	7	18
T_5	20	20	20	5	10	7	18

Table 2. Mean scores for organoleptic evaluation of millet based nutribar

Treatments	Sensory attributes						Total Score
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	
T_1	9.0(5.00)	9.0(5.00)	9.0(5.00)	8.9(4.80)	8.7(4.30)	9.0(4.80)	53.60
T_2	8.1(2.70)	8.0(2.50)	8.5(3.15)	8.37(4.15)	8.6(4.05)	8.7(4.05)	50.27
T_3	8.0(2.50)	8.0(2.50)	8.2(2.45)	7.58(2.80)	8.05(2.55)	8.02(2.50)	47.85
T_4	8.0(2.50)	8.0(2.50)	8.2(2.45)	6.93(2.15)	7.58(2.25)	7.84(2.10)	46.55
T_5	7.9(2.30)	8.0(2.50)	8.2(2.45)	5.86(1.10)	7.54(1.85)	7.62(1.75)	45.12
Kendall's w value	0.596 **	1.000 **	0.594 **	0.921 **	0.584 **	0.796 **	

Values in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

In the present study based on sensory evaluation, the treatment T_1 (60% sorghum) was best selected. The treatment T_1 has the highest mean score in terms of parameters like appearance (9.0), colour (9.0), flavour (9.0), texture (8.9), taste (8.7), overall acceptability (9.0) and treatment T_4 has the least mean score in terms of parameters colour (8.0), taste (7.54), flavour (8.2), texture (5.86), overall acceptability (7.62). Among the millets, sorghum showed the best puffing property compared to pearl millet and finger millet and this could be the reason for the treatment T_1 (60% sorghum) to show best organoleptic qualities. Puffing essentially creates a crisp, aerated product with desirable sensory qualities. The highest total score of 53.60 was noticed in T_1 followed by 50.27 (T_2), 47.85 (T_3), 46.55 (T_4) and 45.12 (T_5) respectively. Kendall's value shows that there was significant agreement between the judges at 1% level. Similarly, a nutribar was developed by Zahra *et al.* (2014) using puffed rice, dried apricot paste, roasted black gram, barley, jaggery and chocolate were found acceptable with an overall acceptability score of 7.56.

Research conducted on millets has established that processes like milling, fermentation, germination, popping, puffing, extrusion, roller drying, enhances protein quality, *in vitro* digestibility and availability of macro and micronutrients (Arora *et al.,* 2011).

Based on sensory evaluation, the treatment T_1 was the best selected and hence the nutritive value of selected millet based nutribar was analysed and was observed to have energy 435.18 kcal 100 g^{-1} and carbohydrate 58.7 g 100 g^{-1}. According to a study conducted by of Verma *et al*., (2018) reported that carbohydrate content of sorghum based cereal bar was 43.22 g 100 g^{-1}.

The protein content of millet based nutribar in the present study was 8.02 g 100 g^{-1} and similar result was observed in another study conducted by Samuel and Nazni (2020) where the protein content in foxtail millet meal replacement bar was in the range 7 to 9 g 100 g^{-1}. Another study by Ravindra and Sunil (2018) showed that protein content of 3.32 g 100 g^{-1} in puffed cereal bar. The protein content of commercially available yoga bar (multigrain energy bar) is 5.3 g 100 g^{-1} serving.

Fat content in selected nutribar in the present study was found to be 18.7 g 100 g^{-1}. Verma *et al.* (2018) also found the fat content in the range of 20.34 to 20.6.2 g 100 g^{-1} in sorghum based cereal bars.

The crude fibre content in the selected nutribar was 4.22 g 100g^{-1} which was higher than the fibre content noticed by Brito (2004) in homemade cereal bars (3.44 g 100 g^{-1}) and Escobar *et al*., (1998) in cereal bars with toasted amaranth flour. The variation in fibre content from reported values can be attributed to difference in raw ingredients used and its quantity. The moisture content in the selected nutribar was 7.14 % which was lower than the moisture content found in nutribars developed by Shahla (2014).

Nutribar is one of the convenient snack bars with good nutritional value. The manufacturing is also economically feasible and attractive in the current scenario where people are more into shifting towards healthy lifestyle. The present study on standardisation of millet based nutribar and its quality evaluation reveals that puffing is one of the easy and economic processing methods to prepare ready-to-eat products with enhanced nutritional and organoleptic qualities. The puffing ability of sorghum has made the product with 60% sorghum (T_1) more acceptable in texture, appearance, flavour and overall acceptability in sensory quality followed by the nutribar (T_2) i.e. 50% sorghum and 5% pearl millet and finger millet each. The selected nutribar was also a good source of protein, carbohydrate and fibre and was low in moisture content which helps in maintaining shelf life. The study has also brought light into the processing industry to bring maximum utilization of underutilised crops, to diversify processing operation and provide healthy options for a healthy world.

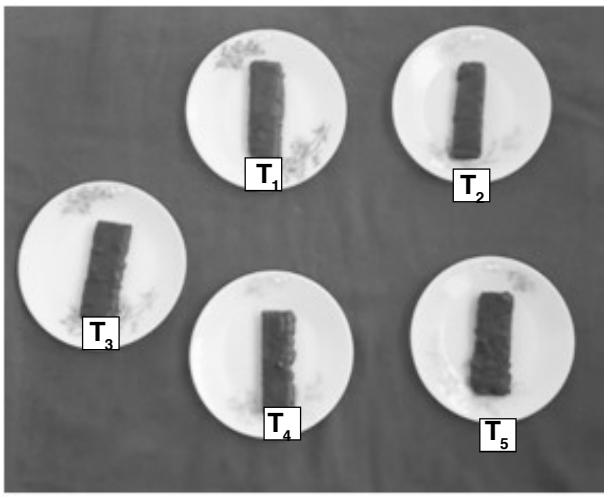

Plate 1. Millet based Nutribar

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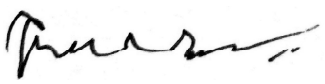

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