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Review Article
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EMERGING STRATEGIES FOR ENHANCING EXTERNAL AND INTERNAL P USE EFFICIENCY IN DIFFERENT CROPS/CROPPING SYSTEMS

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ABSTRACT

Phosphorous Use Efficiency of crops is evaluated in terms of apparent recovery, agronomic efficiency and physiological efficiency and is generally low in crops. The agronomic management, fertiliser management , soil management and development of efficient plant root systems, using mycorrhizal association and plant microbial strategies are some of the strategies developed to improve P use efficiency in different crops/ cropping systems. Among the various fertilizer management strategies fertigation is best approach as it not only increases the efficiency but also increases yield and protects environment. P utilization can also be increased by increasing the effective root area and by modifications in rhizosphere. However to increase the P use efficiency in India measures should be advocated by the Govt. to encourage use of partially acidulated phosphate rocks which are less costlier than SSP in neutral to alkaline soils with medium P in long term crops and cropping systems. Further focused research on development of CRF's like polymer blended P, exchanger P, coating of P with nano particles and varieties with high P acquisition efficiency is essential.

Use efficiency of fertilizer P by the crop is very low and varies from 8 to 33% depending on the nature of crops and soils (Aulakh Pasricha, 1991). Its use efficiency in crops depends on availability of P from secondary reaction products formed in the soil due to transformation of fertilizer P.

Phosphorus use efficiency (PUE) in crops is being evaluated in terms of apparent recovery, agronomic efficiency, and physiological efficiency. Apparent recovery and agronomic efficiencies are used to measure external PUE *viz.,* efficiency of applied P and soil P, whereas physiological efficiency gives measure of internal efficiency of P in the plants. Some researchers are also using P harvest index (PHI) as the measure of internal PUE. Recently, Johnston and Syers (2009) proposed the P Balance Method for computing PUE which may be applicable to high P soils. In this method, PUE is computed as, PUE = Total P removal by crop/amount of P applied.

Several strategies have been developed to improve P use efficiency in different crops/cropping systems which are highlighted in this paper.

1. Agronomic Management Strategies

Suitable crops/varieties, optimum dates of sowing/planting, optimum plant density, weed control, water management are essential for higher phosphorus use efficiency (PUE).

2. Fertilizer Management Strategies

Fertilizer management strategies can be grouped in to two categories.

Product strategy: Primary focus is on product features *viz.,* coated fertilizers , slow-release fertilizers, nitrification inhibitors, urease inhibitors etc. which enhance efficiency of fertilizers.

Fertilizer Management strategy: Primary focus is on nutrient management *viz.,* split application, right time, deep placement, variable rate (time, space, precision farming) which can enhance efficiency of fertilization.

2.1 Fertilizer Management Strategies

2.1.1 Fertilizer Best Management Practices

5 R's (Right Product, Right Rate, Right Time, Right Place and Right Method) continuously guide the efficient P management for higher crop yields and PUE.

For maximum efficiency from P fertilizer, band application is the best. But as fertility levels increase, the banding advantage disappears. So whether to band or broadcast depends greatly on the management philosophy of the grower. Banding does offer the following advantages (Tiwari, 2001):

- May allow use of lower rates than broadcast to achieve the same yield.

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- Reduces fixation of P.
- Places the P close to the root zone so that it becomes positionally available to the young, restricted root system.
- Provides an opportunity for enhanced use efficiency of P and at the same time increases yields by combining placement and recommended rates.

In acid soils, water insoluble sources such as phosphate rock can be used with advantage, wherein to maximize soil and fertilizer contact, broadcasting of P fertilizer especially citric acid soluble sources followed by incorporation in the soil may be more useful for enhancing 'P' use efficiency.

In methods of P application to crops, three additional practices have been reported in literature where in some success has been obtained are:

- Dipping seedling's roots in phosphate slurry.
- Soaking of potato tubers in 1.5% single superphosphate solution for 6 hours.
- Coating of P fertilizer with bio-gas slurry.

2.1.3 Preferential Application of Fertilizer P to Crops in Cropping System

Preferential application of fertilizer P to crops in a cropping system mainly depends upon the (i) nutrient requirement of individual crops (ii) the extent of response of crops to a particular fertilizer nutrient and (iii) the capacity of crops to utilize the residual fractions of soil nutrients. Based on this hypothesis several experiments have been conducted to develop strategies of preferential application of fertilizer P to crops in a cropping system for attaining maximum fertilizer utilization efficiency through higher crop responses (Table 1).

2.1.4. Integrated Nutrient Management Strategies

The basic concept underlying the principle of integrated nutrient management (INM) is to maintain or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients.

Organic manures alone cannot supply sufficient P for optimum crop growth because of limited availability and low P concentration. The organic manures when applied with fertilizer P decrease P adsorption/fixation and enhance P availability in P-fixing soils (Reddy *et al.* 1999b). Organic anions formed during the decomposition of organic inputs can compete with P for the same sorption sites and thereby increase P availability in soil (Iyamuremye *et al.* 1996) and improve utilization by crops. Combined application of

Table 1: Preferential application of fertilizer nutrients to crop in a cropping systems

Cropping sequence	Strategy
Rice-wheat, Pearlmillet-wheat Soybean-wheat	Apply phosphorus to wheat (*rabi*) and skip P application to *kharif* crops
Maize-wheat, Sorghum-wheat	Prefer to apply P to wheat
Gram-rice	Apply superphosphate to gram and harness the residual effect on rice
Sorghum-castor	Apply P at recommended dose to sorghum and castor crop may be given the reduced dose
Potato based cropping system	P should be applied to potatoes in crop rotation
Groundnut-wheat	Apply recommended dose of P to wheat and skip P application to groundnut

Source: Acharya *et al.* (2003)

2.1.2 Fertigation

Fertigation seems to be the best fertilizer management approach in intensive agriculture, as it is used to increase efficiency of fertilizers, increase yield and protect environment. Iqbal *et al.* (2003) reported that lower dose of P (22 kg P ha^{-1}) applied through fertigation resulted in significantly higher grain yield than the full dose of applicator (44 kg P ha^{-1}) by broadcast.

fertilizer P and manure significantly improved the inorganic P solubilizing activity of rhizosphere soil, which ranged from 0.87 to 1.53 ug TCP/g soil/day and organic P mineralizing rate. Studies on transformations of fertilizer P in the presence of farmyard manure in vertisols revealed that when fertilizer P applied alone the excess P mostly accumulated in labile inorganic pools (Sammi Reddy *et al.*, 1996). But application of FYM with fertilizer P helped in accumulation of excessive applied P in labile and moderately labile organic P pools there by increased the long-term supply pool of P in vertisol. All these mechanisms of transformations of P resulted from FYM application with fertilizer P leads to higher P use efficiency in crops. Reddy *et al.* (1999c) observed higher apparent P recovery by soybean-wheat system on Vertisol with a combination of fertilizer P and manure (Table 2). The INM strategies developed for different cropping systems all over the country are compiled and published earlier (Acharya *et al*, 2003).

2.1.5 Strategies of P Management in Acid Soils

At mildly acidic conditions, availability of P increases but with further increase in acidity P reacts with active Fe and Al to form insoluble compounds. It has been reported that 86% of P in super phosphate got converted to unavailable form within 15 days of application (Mandal and Khan, 1972). Excess of Al in soil solution reduce the uptake and transport of P in plants.

Liming improves the base status, inactivates Fe, Mn and Al in soil solution and thus reduces P fixation. Improvement in the availability of soil and fertilizer P by liming the acid lateritic soils have been reported (Panda and Mishra, 1970). In Orissa, application of lime at the rates 1000 kg $CaCO_3$ equivalent per hectare sustained a pH of 5.0 for 2 years. Different doses of lime starting from 1/20 lime requirement to full lime requirement was found superior to increase grain yields of pulse and oil seed crops (Mathur, 1992). Other strategies for enhancing P utilization efficiency in different cropping systems on acid soils are presented in Table 3.

Table 2: Apparent phosphorus recovery (APR) of fertilizer P in soybean and wheat (mean of 5 years)

Manure dose (t/ha)	Rate of fertilizer P (kg P ha^{-1})							
	0	11	22	44	0	11	22	44
	APR by soybean (%)				APR by wheat (%)			
0 (0)*	-	36.6	30.0	19.0	-	35.1	27.8	17.7
4 (5.6)	-	44.1	31.8	19.1	-	33.4	32.8	19.2
8 (11.2)	-	46.5	35.2	22.7	-	35.9	33.9	23.1
16(22.4)	-	47.0	35.8	23.2	-	40.3	38.5	26.9
Mean	-	43.6	33.2	21.0	-	36.2	33.2	21.6

*Figures in parenthesis are P applied through manure

Table 3: Strategies for enhancing P use efficiency in crops in acid soils

Cropping System	Agro-climatic zone	Strategy
Maize-wheat	Western Himalayan region (pH <6.0)	Apply 60 kg P_20_5 ha^{-1} as a mixture of SSP and rock phosphate in a ratio of 1:2 to maize. However, apply SSP to following wheat for higher FUE.
Rice-rice	Eastern Himalayan region (pH<5.1)	Apply 30 kg P_2O_5 ha^{-1} to summer as well as monsoon rice in the form of rock phosphate or a mixture of SSP and RP in 1:1 ratio.

Cropping System	Agro-climatic zone	Strategy
Rice-rice	Brahmaputra Valley	Apply MRP at 40 kg P_2O_5 ha^{-1} at 20 day before rice transplanting.
Rice-rice	Lower Gangetic Plain region	Use SSP and rock phosphate in 1:2 ratio as basal dressing for higher P use efficiency.
Rice-rice	Central Plateau & Hills region	Recommended P dose is 60 kg P_2O_5 ha^{-1} as rock phosphate.
Pulses	Southern plateau & Hills region	I. Rhizobium inoculated seed should be treated with 1.5 kg of finely powdered lime (300 mesh). II. Liming rate should be determined by soil test method and the rate should be that it can only upset the Al toxicity and does not impair the K and Ca balance.
Rice-rice	East Coast Plains & Hills region West Coast Plains & Hills region.	Apply 60 kg P_2O_5 ha^{-1} as rock phosphate 3 weeks before transplanting.

Source: Subba Rao *et al*. (2004)

2.1.6 Residual (accumulated) P Management Strategies for Higher Efficiency

Continuous application of P fertilizers to a crop in a cropping system leads to accumulation of P in soils mostly in unavailable pools, which in turn benefits the succeeding crops. Soil fertility maps prepared by Motsara (2002) showed that about 20% of Indian soils are high in available P. Soils rich and poor in available P status need different strategies for saving costly P fertilizers through higher use efficiency in different crops. These strategies include (i) P prescription based on soil test and target yield, (ii) Residual P management in cropping systems and (iii) Maintenance P fertilization.

(i) P Prescriptions based on Soil Test P and Target Yield

Soil testing is a must for economizing the use of P in different crops for obtaining optimum yields. Fertilizer and manure P prescription equations developed by AICRP on STCR (Soil Test Crop Response Correlations) on the basis of P requirement of crops for a target yield and soil test P value were found to be efficient in economizing the P use as compared to general recommended doses of P to various crops.

(ii) Residual P Management

In a number of studies, significant increase in grain yield has been registered due to residual phosphate (Sammi Reddy *et al.*, 2003b). Recently, Sammi Reddy *et al*. (2003b) compared the residual effect of P applied to soybean on subsequent wheat and soybean with that freshly applied P to these crops. Their results showed that the application of 90 kg P_2O_5 ha^{-1} to only soybean in a soybean-wheat system produced statistically similar yields of soybean and wheat crops to that of application of 60 kg P_2O_5 ha^{-1} to both soybean and wheat. This strategy had saved about 30 kg P_2O_5ha^{-1} P in a soybean-wheat annual rotation. Such P management strategies which consider cropping system as a whole rather than a single crop for major cropping systems grown in various agro-climatic zones have been compiled (Subba Rao *et al.*, 2004).

The approach "P Bank in soil" is more applicable to P rich soils with intensive farming for sustainable environment. The studies conducted at Jabalpur showed that the vertisols with high to very high available P (20 – 22 mg P kg^{-1} soil) might support two rotations of soybean-wheat without P application. After two rotations, the available P may decline to below critical limit and fresh application of recommended dose of P is needed (Sammi Reddy *et al.*, 2003b).

(iii) Maintenance P Fertilization

In order to build up soil P to the critical value, it may be necessary to accept a lower recovery of added

P for a number of years. Once the critical level is achieved in many arable cropping systems, the amount of P required to maintain it is often similar to that removed in the crop (i.e. there is a very high P-use efficiency). It is suggested to apply only maintenance dose of P that equals to amount of P removed by the previous crop when the available P status is higher than 14 mg P kg^{-1} soil. Soil phosphate maintenance fertilization in soybean-wheat rotation on a Vertisol (available P 5.84 mg kg^{-1}) showed that application of P at the rate equivalent to P removal by each crop, through 5 t FYM plus 8 kg fertilizer P ha^{-1} or 10 t FYM/ha to soybean and 10 kg fertilizer P ha^{-1} to wheat was good enough to obtain the target of 2 t soybean and 4 t wheat yields ha^{-1} and helped to maintain P fertility at near initial level.

2.2 Fertilizer Product Strategies

The water-soluble form of P is readily available to plants. The efficiency of P sources varies depending upon (i) proportion of water soluble P (WSP), and (ii) soil reaction. Generally, in neutral to alkaline soils, materials containing WSP are more efficient than materials containing P as citric acid soluble or water plus citric acid insoluble, while in acid soils the latter materials can become equally efficient. When WSP fertilizers are added to soil, reactions take place between the soil constituents and the fertilizer solution. Consequently the soil solution gets enriched with one or more P compounds and results in the precipitation of the reaction products. As a result the P fertilizer use efficiency never exceeds 20%. Several indigenous techniques were developed for regulating the P release from WSP fertilizers to enhance the utilization of applied P by wheat – green gram cropping system. Biogas slurry coated SSP was found an effective treatment for increasing the P utilization by wheat in sandy loam soil while SSP applied with sodium silicate was so in clay loam soil. In the sandy loam soil, SSP with sodium silicate resulted in the highest utilization of applied P with an increase of about 9% over SSP alone.

Gel Based CRFs: New gel-based CRFs were developed by mixing and processing N, P and K fertilizers with natural and semi-natural organic and inorganic materials (Hong and Zhang, 2011). CRFs mixed with natural/semi-natural organic gels or inorganic gels improved NUE by 17-32%, PUE by 8-16% and KUE by 5-18% in maize over common fertilizers.

Coated P Fertilizers: Polymer coating on MAP improved the P use efficiency and yield of barley over uncoated MAP (Malhi *et al*., 2002).

3. Soil Management

Eroded soil and its associated P is one pathway by which P is transported from soil to surface water. Soil erosion can be minimized by adopting well-tested technologies, such as cultivation and planting along the contour, and maintaining a soil cover of actively-growing vegetation or plant residues. Simple procedures to minimize losses of P in subsurface runoff include not applying P fertilizers and organic manures to cracking soils while the fissures remain open, and not applying them to soils that are dry and hard or saturated with water. A further approach to minimizing soil erosion is to replace ploughing with zero-tillage or minimum tillage.

4. Efficient P Utilization through Efficient Plant Root System

4.1 Increasing the root surface/soil contact area

This can be achieved by modifying the root morphology. For a constant level of root biomass, roots with higher specific root length (i.e. roots with smaller diameter) can cover a larger surface area. A second approach for achieving the same objective is through increased root hair development. Root fitness or branching is an important determinant of P uptake efficiency in wheat (Jones et al., 1989). Third approach is that root architecture and rooting depth may influence P extraction from soils. Studies using ^{32}P in soils have suggested that most temperate and tropical tree species take up most of their P from very near the surface (Horrison et al., 1988). However, plants may adjust rooting depth and architecture in the face of nutrient competition.

4.2 Increasing the effective root area

Root symbiosis with arbuscular mycorrhizal fungi (AMF) has been shown to enhance P absorption by increasing the effective root area. The AMF infection improves P influx (P uptake per unit root length). The information available on the genetic diversity present among wheat cultivars to associate with VAM is not consistent (Vlek *et al*., 1996). This may be true with other major crops which needs further research.

4.3 Increasing nutrient availability through rhizosphere modification

Root exudates, ranging from protons to complex organic molecules, can influence nutrient availability and uptake. Phosphatases have been reported to transform poorly available organic phosphorus, which usually accounts for 40-50% of a plant's total P supply, into inorganic forms available to the plant. There are genotype differences in root phosphatases excreted or bound at the root surface (Mclachlan, 1980). Screening of crop varieties for both higher yields and PUE is essential for economic and sustainable P use.

5. Mobilization of P through Mycorrhizal Association and Earthworms

The P uptake efficiency of the plant is the ability of the root system to acquire P from the soil and accumulate it in the shoots. The most realistic solution is the use of mycorrhizal fungi that have the ability to acquire P and give high yield under limited P supply (Marschner, 1995). Mycorrhizae are important for many plant species when grown in P-deficient soils, but they are much less effective where soil P status is adequate. Application of high rate of fertilizer P (44 kg P ha^{-1}) reduced AMF colonization in roots, which was 15% lower than in control plots both in soybean and wheat. There has been little success with soil introduction of improved species of mycorrhizae, selected for improved P transfer to the host plant, because of competition from the indigenous population.

Earthworms enhance nutrient availability through casting mainly in tropical soils. The positive effects of earthworms on the availability of N and P to plants is due to increased microbial populations and hence enzyme activity in the casts (Tiwari *et al.*, 1989). Soil ingestion of earthworms increased the available P by 2 times in red soils and by 3 times in black soils as compared to non-ingested soils.

6. Plant and Microbial Strategies

There are three potential strategies by which plants and microorganisms might be used to increase production in low P soil or to reduce the amount of P fertiliser needed to maximise production:

(i) **'Root foraging strategies'** that improve acquisition of soil P, support higher yields in low P soil and thus lower the critical P requirement for plant growth. This enables fertilised agriculture to be operated at lower plant available P concentrations and this, in turn, can slow the rate at which P accumulates in moderate to high P-sorbing soils (Simpson *et al.* 2011).

(ii) **Soil P 'mining strategies'** that enhance the desorption, solubilisation or mineralisation of P from sparingly-available pools (Lambers *et al.* 2010) and slowly mineralising or resistant organic P pools in soil (Richardson *et al.* 2005). Mining P from agricultural soils is not, in itself, sustainable. However, the objective of this strategy is to increase the turnover of P in sparingly-available P pools and thus to also slow the net accumulation of P that occurs when moderate to high P-sorbing soils are fertilised.

(iii) Plants with improved **'internal P-utilisation efficiency' (**i.e. more plant yield per unit of P uptake) could directly reduce the amount of P fertiliser required for agricultural production. Internal P efficiency is employed to extreme levels in slow-growing species adapted to low P landscapes (Lambers *et al.* 2010), but is also found in some of the plant species used in agriculture which needs to be exploited.

7. Future Research and Policy Needs

(i) Policies to promote direct use of phosphate rock and its modified products: In India phosphate rock deposits have been identified in various locations, with reserves estimated to be around 260 million tonnes (FAI, 2006) out of which 15 Mt phosphate rock are of high grade and about 245 Mt is of low grade phosphate rock with an average content of 12% P_2O_5. Though use of ground raw phosphate rocks can reasonably be effective means of P supply in acid soil conditions, under neutral to alkaline soil environment the effect is almost non-existent. Even under acid soil conditions, Indian phosphate rocks are not very effective because of their poor reactivity. Moreover, extent of occurrence of acid soils is not more than one-third of India, leaving a nearly two-third of the area falling in the neutral to alkaline soils category.

To match the P needs of the much larger neutral to alkaline soils, indigenous phosphate rocks need to be made them more effective through modifications in the P release pattern of phosphate rocks. Therefore, lot of research work has been done in India during 1980s and 1990s to develop techniques for mobilization of P from insoluble phosphate rocks. A number of modifications have been evaluated to determine the possibilities of improving the agronomic effectiveness of the phosphate rock. Such possible ways of bringing modifications in the reactivity of phosphate rocks or modified phosphate rocks are,

1. Partially acidulated phosphate rocks
2. Phosphate rock – SSP mixtures
3. Compacted Phosphate rocks
4. Phosphate rock – gypsum mixtures
5. Phosphate rock – elemental sulphur mixtures
6. Phosphate rock – pyrites mixtures
7. Phosphate rock – organic manure mixtures
8. Phosphate rock – phosphate solubilizing bacteria (PSB) mixtures
9. Thermally Promoted Phosphate Rocks

Phosphate rock is also classified as the fertilizer in FCO (1990). Despite these measures, phosphate rocks and other minerals are not readily available in the market and hence farmers are not accessible to them. In place of SSP, government should encourage the use of partially acidulated phosphate rocks which may be less costlier than 100% acidulated SSP in acid soils, in neutral to alkaline soils with medium to high available P content, in long-term crops and cropping systems etc.

(ii) Controlled Release Fertilizers (CRFs): Future research in India should focus on product strategies such as preparation and evaluation of polymer blended P fertilizers, exchanger P fertilizers, coating of P fertilizers with nano particles of different organic and inorganic materials.

(iii) The role of improved soil structure of the surface soil under reduced/zero tillage in offsetting negative effects of stratification on available-P distribution needs further investigations.

(iv) If plant breeding is to contribute to mitigating an unsustainable global P cycle, then high-P use efficiency (PUE) traits must ultimately complement high P acquisition efficiency (PAE) traits in crop cultivars.

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Research Article
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IDENTIFICATION, CHARACTERIZATION AND EVALUATION OF HIGH AMYLOPECTIN SORGHUM (*Sorghum bicolor* (L.) Moench) GERMPLASM LINES

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ABSTRACT

Exploring alternate uses for sorghum has become imperative owing to the decreasing area under sorghum. Among the diverse alternatives available, high amylopectin sorghum can serve for industrial uses for ethanol, adhesives, lubricants among others. Thirteen high amylopectin lines were identified from among the 4000 germplasm lines tested using rapid iodine technique. These 13 high amylopectin lines were evaluated in four environments for agronomic, yield and quality traits along with checks. Wide variability was found among the germplasm lines. The lines interacted significantly with the environment and the interaction effects were also significant though the numerical differences were marginal. Based on grain color, grain yield and amylopectin content, the germplasm lines IS 2269 in red grain color background and IS 5624 in white grain color background were found promising for grain yield as well as early flowering.

Sorghum occupies an important place in addressing the food and nutritional needs of people residing in the semi-arid tropics. Similar to maize, sorghum and millets also offer opportunities for industrial utilisation. They form an important raw material for potable alcohol and starch production in industrialised countries. The food, fodder, feed and industrial uses of these crops make them important in the agrarian economy of the developing regions of Africa and Asia having low rainfall and limited irrigation resources. More than 35% of sorghum is grown directly for human consumption; the rest is used primarily for animal feed, alcohol production and industrial products (Gerrano *et al*., 2014). Selection of varieties that meet specific local food and industrial requirements is very important (Anglani, 1998).

Starch is the predominant storage carbohydrate in plants and the most important source of carbohydrate in the human diet where it occupies an important source of energy (Bednar *et al*., 2000). In sorghum grain, starch is the major proximate component (63 to 74 %) and the major energy supplier (Perez-Maldonado and Rodriguez, 2007). Typical levels of amylose and amylopectin in cereal starches are 25-28 % and 72-75 %, respectively, although for starches of some botanical sources, high amylose (up to 70 % amylose) and waxy (<1 % amylose) genotypes also exist (Jane *et al*., 1999). The two starch components have different properties and are not suitable for the same applications (Zobel, 1988). The total starch and the relative proportion of amylose and amylopectin vary considerably within plant species, plant organs, and depend on organ development and growth conditions.

A high value of amylose: amylopectin ratio indicates low glycemic index. The rate of hydrolysis of starch containing high amount of amylopectin was found to be rapid (Frei *et al*., 2003). Starches with higher amylose content will be less susceptible to gelatinization (Dipnaik and Kokare, 2017). Waxy starches are used in different applications mainly as a thickening agent or stabilizer. Amylopectin also has two properties that make this molecule quite popular for industrial uses: bonding well with other compounds and participating in starch retrogradation. Starch retrogradation refers to starch's ability to change from a liquid solution to a gel or thickened substance. This is due to the rearrangement of glucose chains in the amylopectin molecule. These properties allow amylopectin to be used for industrial application such as manufacturing of adhesives and lubricants.

To make sorghum production more remunerative, there is a need to diversify the uses. Identification of high amylopectin lines will help to commercialize sorghum meeting industrial needs. Hence

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the present study was conducted to identify the high amylopectin lines from among the 4000 germplasm lines and evaluate them for agronomic, yield and quality traits.

MATERIALS AND METHODS

Plant material

The 4000 sorghum germplasm lines were obtained from the gene bank of ICAR-Indian Institute of Millets Research located at Rajendranagar, Hyderabad. Rapid iodine staining technique given by Pedersen *et al.* (2004) was used to identify waxy phenotypes in 4000 germplasm lines. About 13 lines were identified to possess high amylopectin content (90 to 100%). These include IS 23964, Hattigudur cross 2, IS 5624, IS 17994, IS 18020, IS 22119, IS 33815, IS 33887, IS 641, IS 829, IS 2269, IS 24346 and IS 27021 (Figure 1). The germplasm lines were advanced with selection for uniformity in agronomic traits.

Experiment

The 13 lines along with two checks (C43, a *kharif* restorer line and M35-1, a *rabi* variety) were evaluated in four environments- Vasanthrao Naik Marathwada Krishi Vidyapeeth, Parbhani and Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2014 *rabi* season and at Indian Institute of Millets Research, Hyderabad during 2016 and 2017 *rabi* seasons. The sorghum accessions were evaluated for days to 50% flowering, plant height, panicle length, panicle width and grain yield. The grain samples obtained after threshing were analysed for total starch and its components.

Biochemical analysis

Starch comprises of amylose and amylopectin. On hydrolysis by glucosidase enzyme, starch is converted into maltose and finally to glycols. The sugars thus obtained were analysed quantitatively using phenol-sulphuric acid as suggested by Southgate (1976) and Dubois *et al.*(1956). Amylose content of the starch was estimated by the iodine binding method (Williams *et al.,*1958). Amylose in flour/ starch is released by treatment with dilute alkali. By the addition of Tri-iodide ion, amylose produces blue colour. The absorbance of blue colour produced in aqueous solution is measured. Amylopectin was calculated as 100 - amylose %.

Statistical analysis

The data was subjected to analysis of variance (ANOVA) for the four environments. A combined ANOVA over four environments was also performed for each parameter using Genstat 12edn.

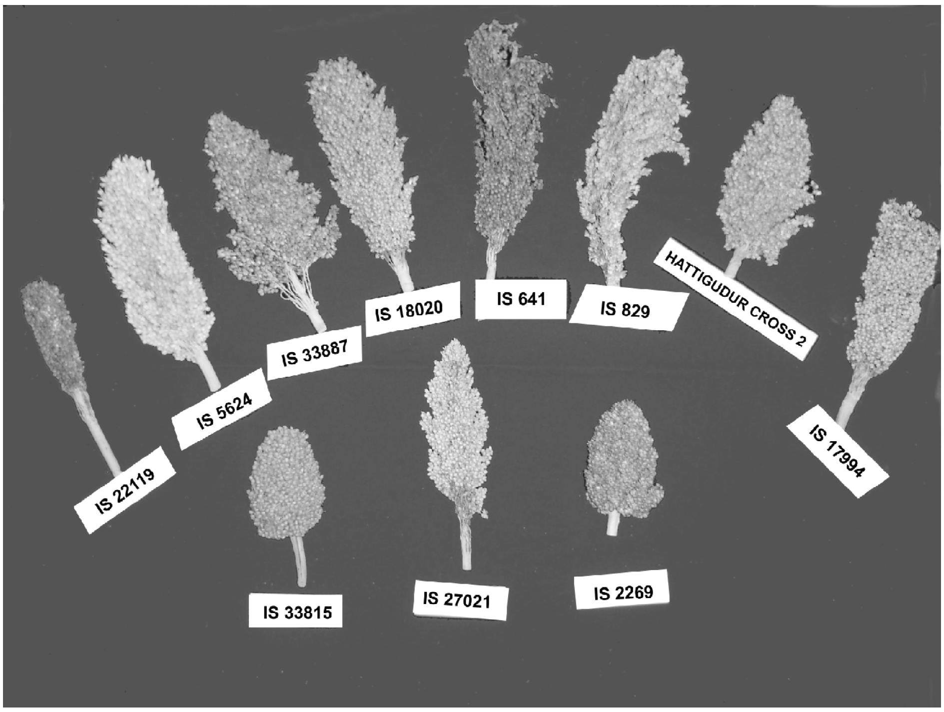

Fig 1. High amylopectin sorghum germplasm lines

RESULTS AND DISCUSSION

The ANOVA revealed that there were high significant (*p* d" 0.01) differences (Table 1) among the accessions (G) for all measured parameters indicating that there was a wide range of genetic variability among them. The variance due to environment (E) and genotype x environment (GE) was also significant for all the traits except for plant height where 'E' was non-significant. Earlier studies also reported that both genetic and environmental factors affected the amylose/amylopectincontent of sorghum (Beta and Corke, 2001). The amylose/amylopectin content has been reported to vary with the botanical source of the starch and is affected by the climatic and soil conditions during grain development (Boudries *et al.*, 2009). The amylose content of rice was also reported to be affected by both environment and genotype (Juliano *et al.*, 1964).Though the ANOVA indicated significant impact of E and GE components, numerically, negligible differences were observed for genotypes as well as genotypes across environments.

Table 1: Genotypic (G) variance, Environment (E) variance and G × E variance for agronomic, yield and quality traits in high amylopectin lines

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	Grain yield (t ha^{-1})	Starch	Amylose (%)	Amylo-pectin (%)
Environment	3	794.88**	90.5	47.95**	4.14**	11.96**	178.37**	86.78**	86.78**
Genotype	14	460.95**	8761.3**	129.84**	5.08**	8.80**	207.25**	19.65**	19.65**
Environment x Genotype	42	168.55**	1870.6**	17.28**	2.35**	4.21**	48.14**	26.84**	26.84**
Residual	118	4.99	342	1.72	0.25	0.48	4.02	0.04	0.04

The germplasm lines flowered from 71 to 93 days (C 43: 73 days, M 35-1: 80 days). The plant height ranged from 128 to 230 cm (C 43: 135cm, M 35-1: 225 cm). The panicle length ranged from 9 to 22 cm while the panicle width ranged from 4.3 to 6.8 cm. The grain yield ranged from 1.53 t/ha to 4.18 t/ha (C 43: 1.72 t/ha, M 35-1: 3.63 t/ha). The germplasm lines IS 2269, IS 5624, IS 33887, IS 23964, Hatigudur cross 2 and IS 33815 had grain yield above 3 t/ha. The germplasm lines had different grain colors. The lines, IS 5624, IS 17994, IS 18020, IS 27021 were cream colored, IS 829 was brown coloured and the rest of them had red colored grains (Table 2). The anthocyanins extracted from easily available red sorghum bran would be a valuable source for antioxidant and antiproliferative activity in food industry (Kumari *et al.,* 2013). Total starch content of the accessions ranged from 59 to 76 % in the present study. Among all accessions, the highest value (76%) was recorded for accession IS 17994. In the germplasm lines, the amylose content ranged from 0.9 to 5.6%. Grains with low amylose contents (1-2 %) are termed "waxy", and are associated with homogenous recessive genes (*wxwxwx*). Non-waxy grains are those with normal levels of amylose (23-28%). According to Ring *et al.* (1982), accessions grouped as heterowaxy contain lower amylose content than non-waxy grains (20%) but display many of the physical attributes of non-waxy grains (McDonough *et al.*, 1998). Wang *et al.* (2008) reported that waxy and heterowaxy sorghum varieties have higher ethanol yields than non-waxy varieties, at the same starch level. The amylopectin content ranged from 99.1% (IS 641) to 98.8 (IS 5624). The waxy (high amylopectin) trait is highly associated with high hot water extract in sorghum malt (Mezgebe *et al.,* 2018). The improved malt quality was probably due to the better starch granule swelling property of amylopectin which could have facilitated hydrolysis by amylases and proteases (Tester and Morrison, 1990), facilitating greater hydrolysis by amylases. As a result, waxy starch is more easily hydrolyzed by α-amylase (Wu *et al.*, 2010).

Based on grain color, grain yield and amylopectin content, the germplasm lines IS 2269 in red grain colour background and IS 5624 in white grain colour background were found promising for grain yield as well as early flowering.

Table 2 : Mean performance of high amylopectin lines for agronomic, yield and quality traits across four environments

	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	Grain yield (t ha^{-1})	Starch (%)	Amylose (%)	Amylo-pectin%	Grain colour
IS 641	71	168	22	5.0	2.51	67	0.9	99.1	Red
IS 829	92	128	19	4.8	1.53	59	1.2	98.8	Brown
IS 2269	76	192	9	4.8	4.18	72	1.8	98.2	Red
IS 5624	78	230	18	5.0	3.10	73	1.2	98.8	Cream
IS 17994	77	176	19	5.3	2.35	76	2.9	97.1	Cream
IS 18020	74	158	19	5.3	2.50	72	5.6	94.4	Cream
IS 22119	84	136	14	4.3	1.82	72	2.4	97.6	Red
IS 27021	89	134	19	4.7	1.87	72	1.2	98.8	Cream
IS 33887	93	201	19	6.8	3.07	73	2	98	Red
IS 24346	80	139	15	5.0	2.30	72	1.4	98.6	Red
IS 23964	83	203	19	6.6	3.60	75	3	97	Red
Hathigudur Cross 2	85	165	16	5.5	3.51	68	2.5	97.5	Red
IS 33815	90	178	10	6.2	4.04	71	1.1	98.9	Red
C 43 (check)	73	135	25	4.0	1.72	71	10.7	89.3	Cream
M 35-1 (check)	80	225	17	5.9	3.63	74	18.9	81.1	Cream
Mean	82	171	17	5.3	2.78	71	3.8	96.2	-
CV(%)	12.7	10.9	7.8	9.3	24.7	2.8	9.1	0.2	-
lsd (5%)	2.115	17.51	2.1	0.47	0.56	1.6	0.15	0.15	-

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Research Article
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IDENTIFICATION OF POTENTIAL DONORS THROUGH GENE PROFILING FOR RICE IMPROVEMENT

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ABSTRACT

The experimental field was laid in RBD design replicated thrice using 30 advanced breeding lines and BPT-5204 as quality check. For characterization of advanced breeding lines seven genes (*Gn1, Gn2, SCM2, SCM3, Gs3, Gw5, Spl14*) and three *QTL*s (*Yld12.1, Yld2.1 and Yld2.1*) for grain yield; two genes (*Gn1* and *Gn2*) for grain number; two genes (*SCM2* and *SCM3*) for strong culm; one gene each for grain weight (*Gw5*); grain size (*Gs3*), filled grains per panicle (*Spl14*) were selected. Upon genotyping, only one advanced breeding line SP-08 showed the presence of the seven yield contributing genes/*QTL*s indicating possibility of higher yield potential. Two advanced breeding lines showed the presence of six yield contributing genes/*QTL*s. They are SP-69 contain (*Gn1, Gn2, SCM3, Gw5, Spl14, Yld2.1*) and SP-70 contain genes/*QTL*s (*Gn1, SCM3, Gw5, Gs3, Yld2.1, Yld12.1*). Whereas four advanced breeding lines showed the presence of five yield contributing genes. They are SP-37 (*Gn2, SCM3, Gw5, Yld12.1, Yld2.1*), SP-55 (*Gn2, SCM2, SCM3, Gw5, Yld2.1*), SP-75 (*Gn1, Gn2, SCM3, Gw5, Yld12.1*) and SP-61 (*Gn1, Gn2, SCM2, Gw5, Yld 2.1*).

Rice (*Oryza sativa* L.) belongs to the family Poaceae and sub family Oryzoideae. As a cereal grain, it is the most important staple food crop in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. Among the rice growing countries, India has the largest area (42.27 m ha) and production (105.24 m t) next to China (144 m t) with an average productivity of 2.49 t ha^{-1}, which is still well below the world's average yield of 4.36 t ha^{-1} (FAOSTAT, 2014). At the current population growth rate (1.5 %), rice requirement of India by 2025 would be around 125 m t (Kumar *et al.,* 2009). To safeguard and sustain the food security in India, it is quite important to increase the productivity of rice under limited resources, especially land and water. Hence, the major challenges have been to produce more rice per unit amount of natural resource.

Low productivity of rice in India is a major concern for food and nutritional security of more than 60% population which is dependent on rice. The increasing scarcity of water for agriculture is becoming a major problem in many countries, particularly the leading rice-producing countries like China and India, where competition for freshwater and growing demands for other sectors are increasing in future (Choudhary *et al.*, 2010).

Plant height and flowering time are two of the important traits that affect plant architecture. Efforts were made in this study to characterize morphologically the-EMS-induced dwarf and early flowering mutants of rice variety Nagina22 and to study their mode of inheritance. Nine true breeding mutants generated earlier by EMS treatment were analysed for differences in their phenotypic characteristics recorded according to the national guidelines for Distinctness, Uniformity and Stability (DUS) (Kulkarni *et al.,* 2013).

MATERIALS AND METHODS

1. **DNA Isolation:** DNA was isolated from the leaf tissue by following Murray's (Murray and Thompson, 1980) protocol. The quantity of DNA was estimated in nanodrop (Thermo Fisher Scientific, United States) as well as in agarose gel

2. **Gene Profiling :** PCR analysis was done for high yielding genes and *QTL*s together with the positive controls and susceptible checks to identify the presence of 10 major known high yielding genes and *QTL*s namely seven yield genes *viz.,Gn1, Gn2, SCM2, SCM3, Gs3, Gw5, Spl14* and three *QTLsviz., Yld12.1, Yld2.1 and Yld4.*1 using molecular markers as described in Devi *et al.* (2015). The markers for genes and QTLs utilized were mentioned (Table 1).

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Table 1: Selected genes and *QTL*s related to yield showed in present study

S.No	Gene /QTL	Trait	Chromosome	Location	Markers
1	*Gn1*	*Grain Number1*	*Chr -1*	5.5Mb-7.9Mb	Gn1A* Gn1A17* Gn1INDEL* RM10499 RM151 RM10382
2	*Gn2*	*Grain Number2*	*Chr-2*	32.7Mb-35.1Mb	RM250 RM208
3	*SCM-2*	*STRONG CULM2*	*Chr -6*	25.9Mb-27.8Mb	SCM2-1* SCM2-2* SCM2-3* SCM2-4* RM20615 RM20458
4	*SCM-3*	*STRONG CULM2*	*Chr -3*	28.07Mb-30.3Mb	SCM3-1* SCM3-2* SCM3-3* SCM3-4* RM1350
5	*Gw-5*	*Grain weight 5*	*Chr -5*	4.2Mb-6.8Mb	RM437 RM18161 RM18089 RM18065
6	*Gs-3*	*Grain Size*	*Chr -3*	16.60Mb-16-70Mb	DRR-GL
7	*SPL-14*	*Panicle length*	*Chr -8*	22.3Mb-24.8Mb	Spl14-12* Spl14-4* RM23237 RM23386
8	*Yld-12.1*	*Yield*	*Chr -12*	45.2Mb-67.3Mb	RM511 RM28166 RM28163 RM28130 RM28099
9	*Yld-2.1*	*Yield*	*Chr -2*	20.7Mb-25.8Mb	RM262 RM263
10	*Yld-4.2*	*Yield*	*Chr -4*	25.8Mb-31.5Mb	RM261 RM16338 RM16373

* Functional markers.

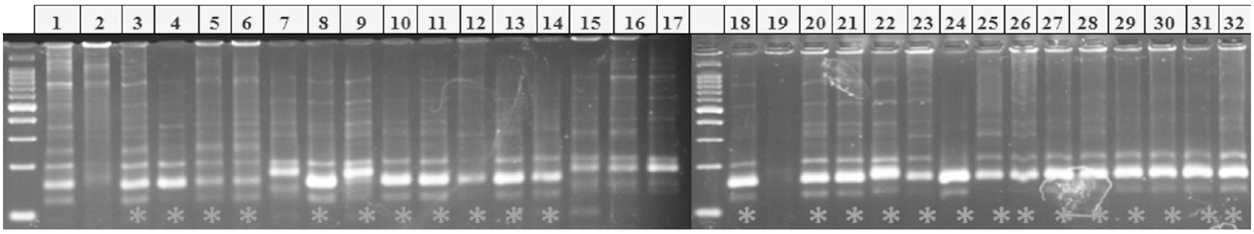
RESULTS AND DISCUSSION

For grain number two genes (*Gn1* and *Gn2*) were selected. For *Gn1* "Habataki" a japonica cultivar selected as a positive control (Ashikari *et al.,* 2005), where as BPT-5204 as negative control. To detect the allelic status of *Gn1* in the advanced breeding lines, six markers were used (Table 1). In that three are the functional markers (Gn1A, Gn1A17 and Gn1INDEL) and three are linked markers (RM10499, RM151 and RM10382). Upon genotyping with these six markers, seven advanced breeding lines showed positive alleles with more than two markers. They are SP-351, SP-70, SP-61, SP-69, SP-25, SP-08 and SP-75.

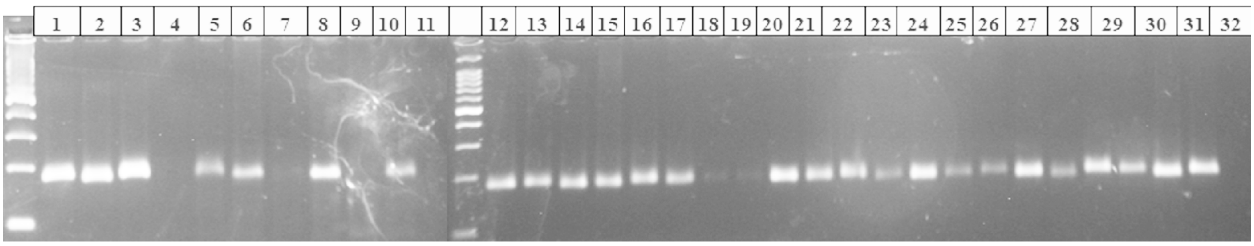
For assessing *Gn2* "(H-2-4)" an indica cultivar was selected as a positive control, where as BPT-5204 negative control. To detect the allelic status of *Gn2* in the advanced breeding lines, two linked markers (RM250 and RM208) were used (Table 1 and figure 1). Upon genotyping, thirteen lines (SP-61, SP-69, SP-55, SP-80, SP-25, SP-13, SP-03, SP-01, SP-34, SP-37, SP-08, SP-75 and SP-57) have the *Gn2* positive alleles for both the markers (figure 2). Grain number is an important factor in determining grain production of rice (*Oryza sativa* L.). The molecular genetic basis for grain number is complex. Here, Chen *et al.* (2013) identified *GRAIN NUMBER 2 (GN2),* a novel gene that is responsible for rice grain number, from "Yuanjiang" common wild rice (*O. rufipogon Griff.).* Transgenic plants overexpressing *GN2* showed more grain number, reduced plant height, and later heading date than control plants.

Figure 1: Genotyping of *Gn2* among advanced breeding lines with markers

RM 250



RM 208



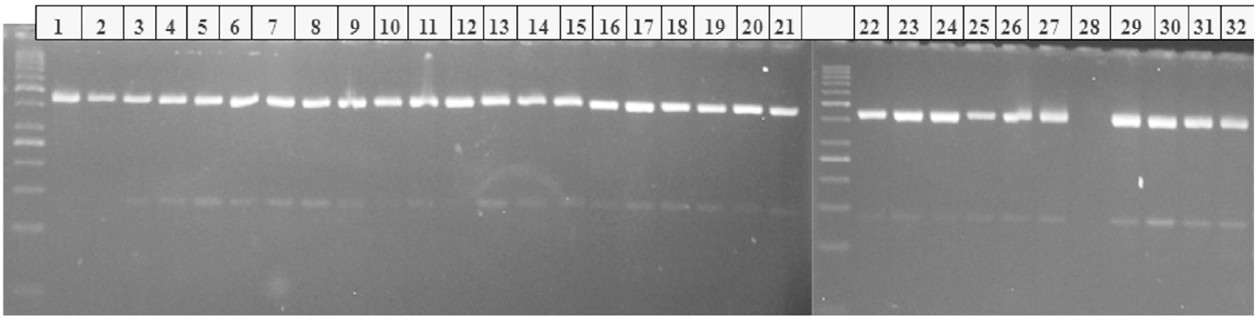
1.MTU 10101 (H-2-4), 2.BPT-5204, 3.IR-64, 4.NDR-359, 5.Jaya, 6.BPT-5204, 7.SP-351, 8.SP-352, 9.SP-353, 10.SP-354, 11.SP-355, 12.SP-356, 13.SP-357, 14.SP-358, 15.SP-359, 16.SP-360, 17.SP-70, 18.SP-72, 19.SP-63, 20.SP-61, 21.SP-69, 22.SP-55, 23.SP-80, 24.SP- 25, 25.SP-13, 26.SP-03, 27.SP-01, 28.SP-34, 29.SP-37, 30.SP-08, 31.SP-75, 32.SP-57.

* Genotypes have positive alleles for grain number (*Gn2*).

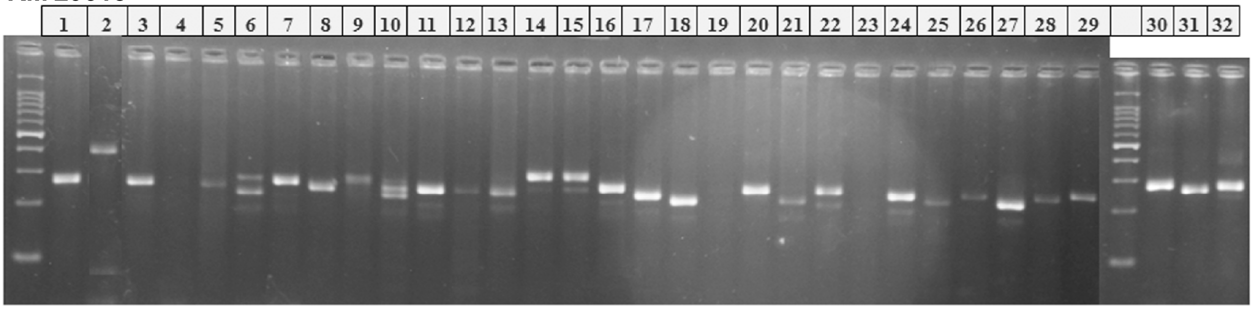
For strong culm trait, two genes (*SCM2, SCM3*) were selected. For both genes "Habataki" a japonica cultivar was selected as positive control, where as BPT-5204 negative control. To detect the allelic status of *SCM-2*, six markers were used (Table 1 and figure 2). In that four are functional markers (SCM2-1, SCM2-2, SCM2-3 and SCM2-4) and two are linked markers (RM20615 and RM20458). Upon genotyping, five lines (SP-351, SP-61, SP-55, SP-08 and SP-57) showed positive alleles for *SCM-2* with more than two markers. Koshihikari *NIL* introgressed with *SCM2* from Habataki showed significantly enhanced culm strength, increased spikelet number and grain yield. This result shows that the gene can be effective in improving lodging resistance, and yield in japonica varieties.

Figure 2: Genotyping of *SCM2* among advanced breeding lines with markers

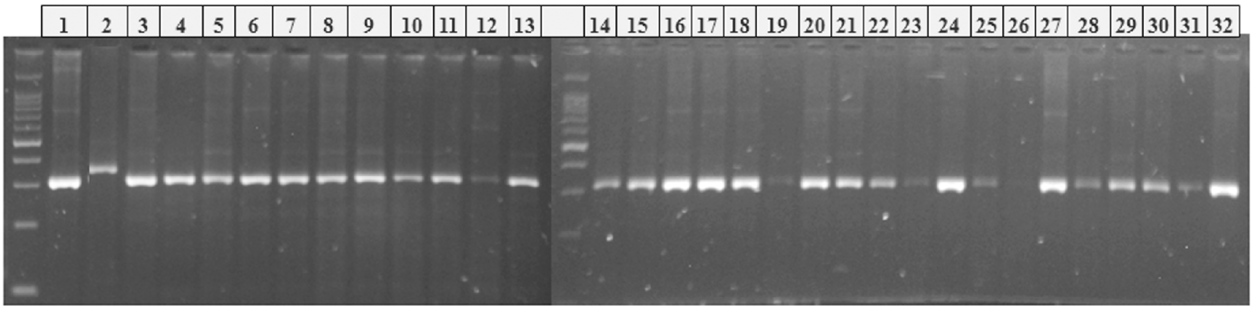
SCM 2- 2



RM 20615



RM 20458



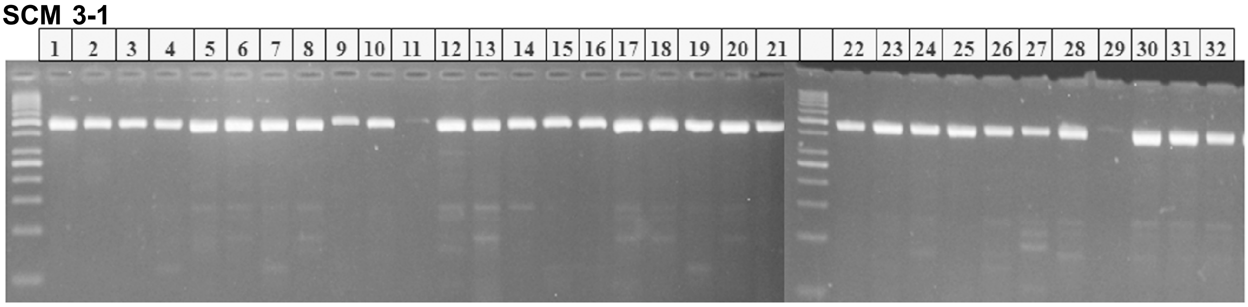
1.Habataki, 2.BPT-5204, 3.IR-64, 4.NDR-359, 5.Jaya, 6.BPT-5204, 7.SP-351, 8.SP-352, 9.SP-353, 10.SP-354, 11.SP-355, 12.SP-356, 13.SP-357, 14.SP-358, 15.SP-359, 16.SP-360, 17.SP-70, 18.SP-72, 19.SP-63, 20.SP-61, 21.SP-69, 22.SP-55, 23.SP-80, 24.SP- 25, 25.SP-13, 26.SP-03, 27.SP-01, 28.SP-34, 29.SP-37, 30.SP-08, 31.SP-75, 32.SP-57.

* Genotypes have positive alleles for grain number (*SCM2*).

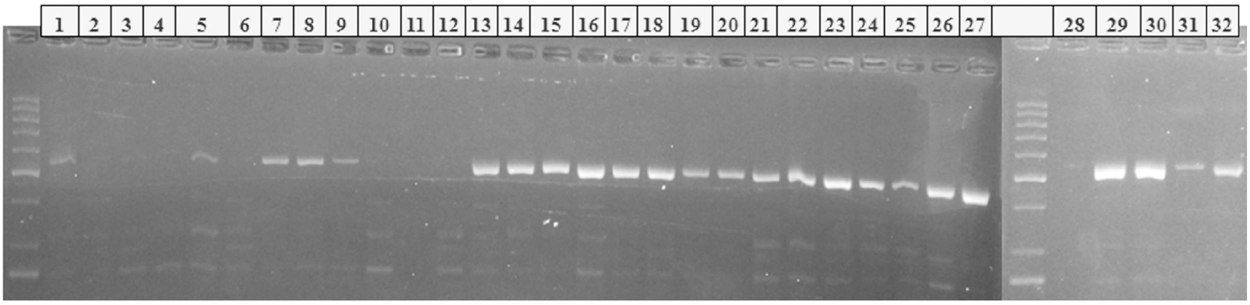
To detect the allelic status of *SCM-3*, in the test lines five markers were used (Table 1 and figure 3). In that four are the functional markers (SCM3-1, SCM3-2, SCM3-3 and SCM3-4) and one is the linked marker (RM1350). Upon genotyping, ten advanced breeding lines (SP-357, SP-358, SP-360, SP-70, SP-69, SP-55, SP-37, SP-08, SP-75 and SP-57) showed positive alleles for *SCM-3* with more than two markers.

Figure 3: Genotyping of *SCM3* among advanced breeding lines with markers

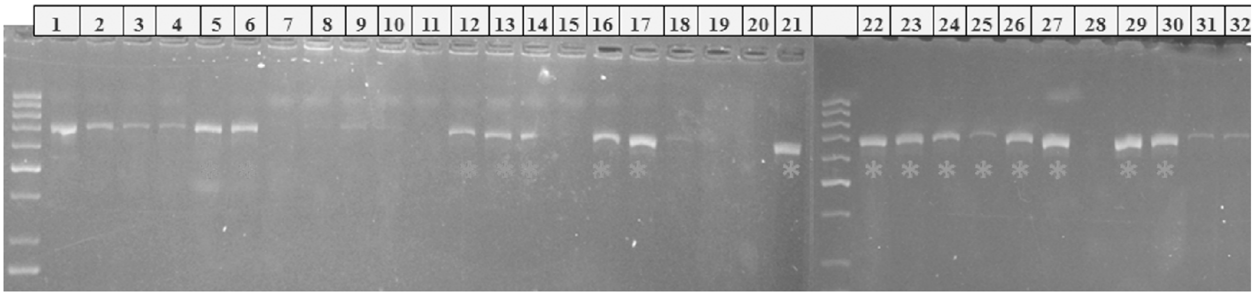
SCM 3-1



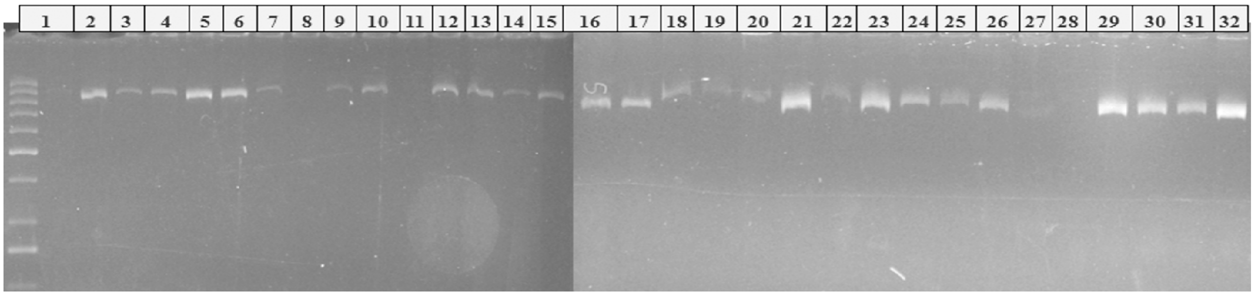
SCM 3-2



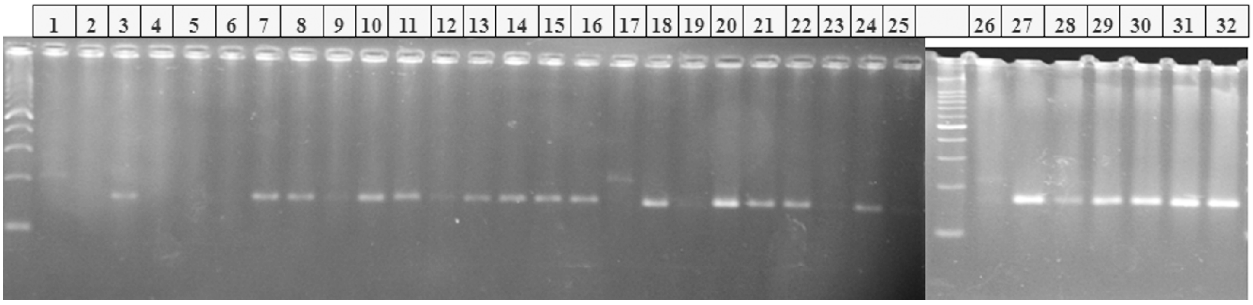
SCM 3- 3



SCM 3- 4



RM 1350



1.Habataki, 2.BPT-5204, 3.IR-64, 4.NDR-359, 5.Jaya, 6.BPT-5204, 7.SP-351, 8.SP-352, 9.SP-353, 10.SP-354, 11.SP-355, 12.SP-356, 13.SP-357, 14.SP-358, 15.SP-359, 16.SP-360, 17.SP-70, 18.SP-72, 19.SP-63, 20.SP-61, 21.SP-69, 22.SP-55, 23.SP-80, 24.SP- 25, 25.SP-13, 26.SP-03, 27.SP-01, 28.SP-34, 29.SP-37, 30.SP-08, 31.SP-75, 32.SP-57.

* Genotypes have positive alleles for grain number (*SCM3*).

For grain weight trait, *Gw5* gene was selected. A "Pre breeding line of Swarna (272)" a indica cultivar was selected as a positive control, where as BPT-5204 negative control for *Gw5*. To detect the allelic status of *Gw5*, four linked markers (RM437, RM18161, RM18089 and RM18065) were used (Table 1). Upon genotyping, twenty lines (SP-351, SP-352, SP-353, SP-354, SP-355, SP-356, SP-357, SP-359, SP-360,

SP-70, SP-72, SP-63, SP-61, SP-69, SP-55, SP-25, SP-01, SP-37, SP-08 and SP-75) showed positive alleles for *Gw5* with more than two markers. Wan *et al.* (2008) identified a *QTL*, *qGw-5* using *Asominori/ IR24 RIL* and *CSSL* populations. Later this *QTL* was narrow down to 49.7-kb genomic region. This finding help the rice researchers across world to use this gene in the breeding programme.

For Grain Size trait, *Gs3* gene "Basmati 370" was selected as a positive control since it is long grain, where as BPT-5204 as negative control (medium slender). To detect the allelic status of *Gs3* one linked marker i.e., DRR-GL was used (Table 1). Upon genotyping, four lines (SP-360, SP-70, SP-63 and SP-80) showed *Gs3* alleles. Using C*leaved amplified polymorphic sequence (CAPS)* markers is Cumbursome and hence replacing *CAPS* markers, a functional marker DRR-GL was developed targeting C/A *single polymorphism (SNP)*. This marker was tested among rice germplasm (Ram kumar *et al.,* 2010).

Spike Length *Spl 14,* "Aikava (273)" was selected as a positive control, where as BPT-5204 negative control. To detect the allelic status of *Spl 14* four markers were used (Table 1), two were functional markers (Spl14-12 and Spl14-4) and two linked markers (RM23237 and RM23386). Upon genotyping only one advanced breeding line (SP-69) showed positive alleles for *Spl 14* with more than two markers.

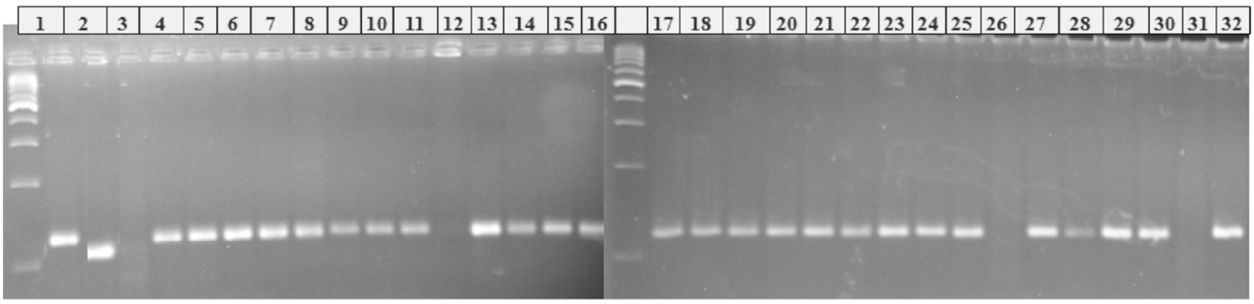
Yield

Three major *QTL*s were contributing for grain yield *Yld 12.1, Yld 2.1* and *Yld 4.1*. For *Yld 12.1* "Near isogenic line of Vandana" were selected as positive control, where as "Varalu" as negative control. To detect the allelic status of *Yld 12.1* in the test lines five linked markers were used (RM511, RM28166, RM28163, RM28130 and RM28099). (Table 1 and figure 4) . Upon genotyping, twelve lines (SP-351, SP-353, SP-357, SP-359, SP-360, SP-70, SP-63, SP-25, SP-37, SP-08, SP-75 and SP-57) showed positive alleles for *Yld12.1* with more than two markers.

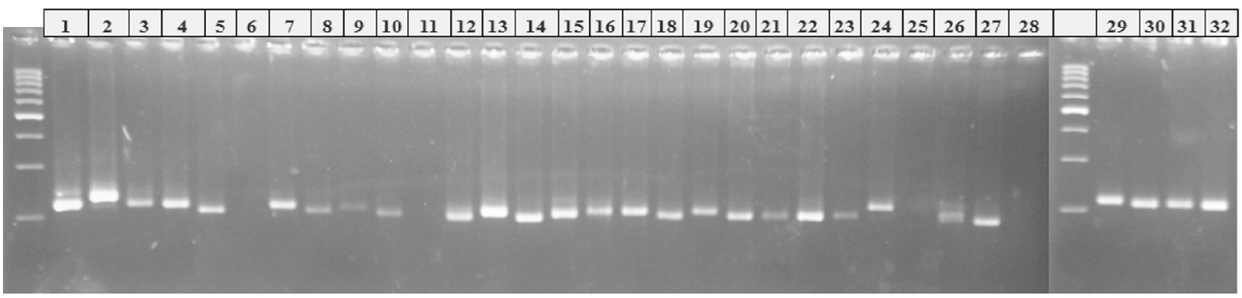
*QTL*s for grain yield, under stress were detected in the centromeric region of *Chromosome 12* (*qtl12.1*). The *CIM* analysis over two year was carried out using all 436 lines, resulted in the localization of this QTL in the interval between RM28048 (45.2 cM) and RM511 (55.5 cM). The additive effect of the Rare allele at *qtl12.1* was 172 kg ha^{-1}, this QTLs explaining 33% of the total phenotypic variance for grain yield under stress. Significant QTLs were also detected under stress conditions in the *qtl12.1* region for biomass yield, harvest index, days to flower, final plant height, flowering delay, drought-response index, and panicle number (Bernier *et al.,* 2009).

Figure 4: Genotyping of *Yld12.1* among advanced breeding lines with markers

RM 28099



RM 28163



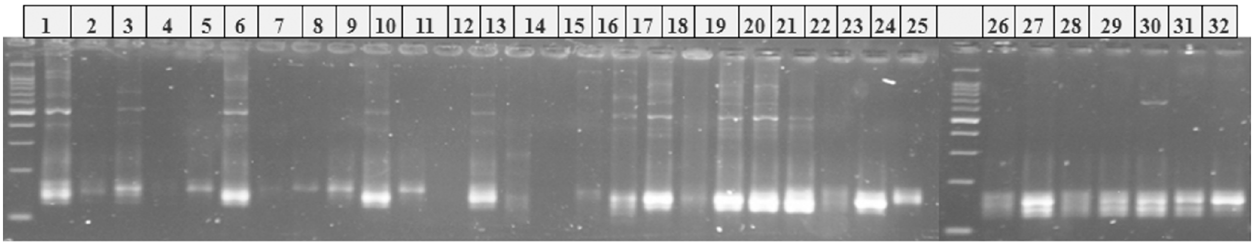
1.Vandana , 2.BPT-5204, 3.IR-64, 4.NDR-359, 5.Jaya, 6.BPT-5204, 7.SP-351, 8.SP-352, 9.SP-353, 10.SP-354, 11.SP-355, 12.SP-356, 13.SP-357, 14.SP-358, 15.SP-359, 16.SP-360, 17.SP-70, 18.SP-72, 19.SP-63, 20.SP-61, 21.SP-69, 22.SP-55, 23.SP-80, 24.SP-25, 25.SP-13, 26.SP-03, 27.SP-01, 28.SP-34, 29.SP-37, 30.SP-08, 31.SP-75, 32.SP-57.

* Genotypes have positive alleles for grain number (*Yld12.1*).

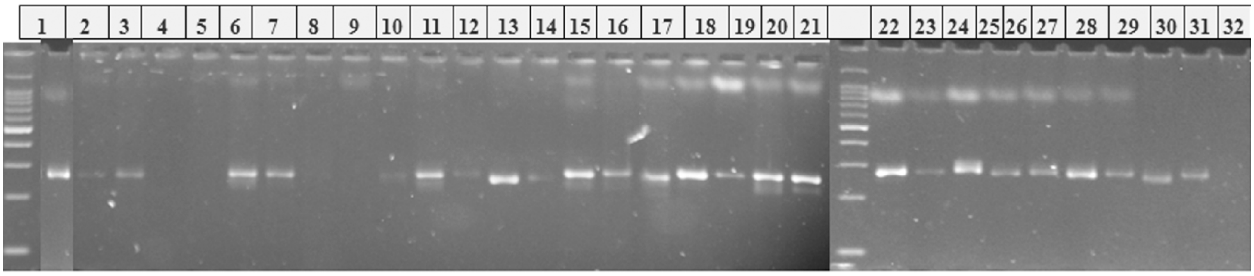
For *Yld2.1* "DRR-50-7" was selected as positive control, where as "BPT-5204" negative control. To detect the allelic status of *Yld2.1* in the test lines two linked markers viz., (RM262 and RM263) were used. (Table 1 and figure 5). Upon genotyping, eleven lines (SP-357, SP-70, SP-72, SP-61, SP-69, SP-55, SP-03, SP-01, SP-34, SP-37 and SP-08) showed positive alleles for *Yld2.1* with more than two markers. The selection process for this QTL was done earlier using three peak markers, with one peak marker for each *qDTY* locus. In the foreground selection, the peak markers reported in an earlier study, namely RM520 (Venuprasad *et al.* 2009) and RM511 (Bernier *et al.* 2007), were used to confirm the presence of *qDTY3.1* and *qDTY12.1*, respectively.

Figure 5: Genotyping of *Yld2.1* among advanced breeding lines with markers

RM 262



RM 263



1.DRR-50-7, 2.BPT-5204, 3.IR-64, 4.NDR-359, 5.Jaya, 6.BPT-5204, 7.SP-351, 8.SP-352, 9.SP-353, 10.SP-354, 11.SP-355, 12.SP-356, 13.SP-357, 14.SP-358, 15.SP-359, 16.SP-360, 17.SP-70, 18.SP-72, 19.SP-63, 20.SP-61, 21.SP-69, 22.SP-55, 23.SP-80, 24.SP-25, 25.SP-13, 26.SP-03, 27.SP-01, 28.SP-34, 29.SP-37, 30.SP-08, 31.SP-75, 32.SP-57.

* Genotypes have positive alleles for grain number (*Yld2.1*).

For *Yld 4.1* "DRR-50-7" were selected as positive control, where as "BPT-5204" negative control. To detect the allelic status of *Yld 4.1* in the test lines three linked markers viz., RM261, RM16338 and RM16373were used. (Table 1). Upon genotyping with these three markers none of the lines showed presence of positive alleles. Sandhu *et al.,*(2017) reported *qDTY2.2*, *qDTY4.1* combination showed higher yield advantage under drought over single QTLs in Samba Mahsuri background indicating the effectiveness as well as positive interactions between these two *QTLs* in multiple genetic backgrounds. The release of IR64 *PLs* with *qDTY2.2* + *qDTY4.1* in India, Nepal, and Myanmar, validate the effect of these *QTLs* in reducing yield loss under reproductive-stage drought stress in variable environments.

Conclusion

Two advanced breeding lines namely SP-69 and SP-70 also showed higher panicle length (*Spl14*) and six yield contributing genes/*QTLs*. SP-37, SP-55, SP-75 and SP-61 advanced breeding lines showed five yield contributing genes/*QTL*s. The advanced breeding lines SP-08 showed better presence of seven yield contributing genes/*QTL*s. So this particular line can be a potential donor to be used in rice improvement programme.

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Research Article
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YIELD SUSTAINABILITY UNDER LONG TERM RICE - RICE CROPPING SYSTEM

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ABSTRACT

A long-term experiment is being conducted with the objective of studying crop productivity and yield sustainability and under continuous rice-rice cropping system under the influence of different nutrient management practices at Regional Agricultural Research station, Polasa, Jagtial, Telangana. This experiment was initiated in *kharif* 2000-01. Treatments (12) consist of different doses, integrated nutrient management, only FYM application, control and one fallow. The present study was conducted during *rabi* 2014-15 and *kharif* 2015-16. The sustainability yield index in both seasons was found to be highest with integrated nutrient management (100 % NPK + 10 t FYM ha^{-1}) (0.617 and 0.615 in *rabi* and *kharif* respectively) followed by 150 % NPK (0.615 and 0.605). It was least under imbalanced fertilizer application of only N (0.508 and 0.571) followed by control (0.542 and 0.564).

Soil is a key natural resource and soil quality is the integrated effect of management on most soil properties that determine crop productivity and sustainability. Good soil quality not only produces good crop yield, but also maintains environmental healthy and consequently plant, animal and human health. With the advancement of intensive agriculture, soils are being degraded at an alarming rate by wind and water erosion, desertification and salinization because of exploitative total farming practices for short term gains. Growing crops without due consideration to total nutrient requirement has resulted in decline in soil fertility (Ghosh *et al*. 2003). Soil quality assessment has been suggested as a tool for evaluating sustainability of soil and crop management practices (Hussain *et al*., 1999).

Rice (*Oryza sativa* L.) is the principal food crop of the world contributing to about 60% of the world's food. India ranks second in rice production with 110.9 million tonnes and productivity of 2.28 t ha^{-1} from an area of 39.47 million hectares. Telangana rice production is 12.9 million tonnes with a productivity of 3.22 t ha^{-1} from an area of 4.01 million ha (Ministry of Agriculture, Government of India. 2011). Higher production requirements for the future to meet the demands of growing population need to be achieved, maintaining the soil quality and sustainability of the productivity at the same time. Increase in cropping intensity with optimum use of production inputs like seed, water and fertilizers and effective plant production measures are the key for sustained crop yields.

In long term experiments, the treatments are applied for a long time sufficient to assess their impact on the resource base. Overall trends and cumulative impact of management systems are best studied through long term experiments. Long term experiments provide a reliable means to study the effect of continuous application of organic manures and inorganic fertilizers on the crop yields and productivity of the soil (Manna *et al.,* 2005). The importance of long term fertilizer experiments in studying the effect of continuous cropping and fertilizer or manure application on soil quality and sustainability of crop production is widely recognized.

MATERIALS AND METHODS

The field experiment was conducted at Regional Agricultural Research Station, Polasa, Jagtial district of Telangana. The farm is geographically situated at 78^0 45' E to 79 ^{0} 0' E Longitude and 18^0 45' N to 19^0 0' N Latitude. The climate of Polasa, Jagtial classified as subtropical. The southwest monsoon occurs usually during June-October second week giving 40-50 rainy days per year. Winter is generally milder at Jagtial and temperature begins to rise from January and reaches peak by May. Weather data were recorded at the meteorological observatory located at the station.

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The present experiment is a part of All India Coordinated Research Project on Long Term Fertilizer Experiment (ICAR) initiated in *kharif* 2000-01. The present study was taken up in *rabi* 2014-15 and *kharif* 2015-16 with a view to study the effect of Long term fertilizer management on Sustainability Yield Index. Twelve treatments were laid out in randomized block design with four replications. The twelve treatments were 50% NPK (T_1), 100%NPK (T_2), 150% NPK (T_3), 100% NPK + HW (T_4), 100% NPK + $ZnSO_4$ (T_5), 100% NP (T_6), 100% N (T_7), 100% NPK + FYM (10 t FYM ha^{-1} in *kharif*) (T_8), 100% NPK –S (T_9), FYM (10 t FYM ha in *kharif* and *rabi*) (T_{10}), Control (T_{11}) and Fallow (T_{12}).

Soil Sampling and Analysis

Soil samples were collected during *rabi* and *kharif* from the plow layer (0.0–0.15 m depth) from each plot after the harvest of *rabi* 2014-15 and *kharif* 2015-16 crop. These samples were partitioned and passed through standard prescribed sieves for further use in a different kind of analysis. The soil samples were air-dried and ground with a wooden pestle and mortar to pass through a 2 mm sieve for determination of soil pH, EC, OC and available micronutrients. Soil pH and electrical conductivity were measured in a 1:2.5 soil/water suspension with digital pH meter and EC meter (Jackson,1967). OC was determined by wet oxidation with sulfuric acid (H_2SO_4) + potassium dichromate ($K_2Cr_2O_7$) (Walkley and Black 1934), available N by alkaline potassium permanganate ($KMnO_4$)–oxidizable N method (Subbaiah and Asija 1956), available P by 0.5 M sodium bicarbonate ($NaHCO_3$) method (Olsen et al. 1954), and available K using Neutral Normal Ammonium Acetate method using Flame photometer (Jackson, 1973).

Sustainability yield index (SYI)

The influence of the practice/treatment on crop yields is directly affected by magnitude of rainfall, irrigation water and other natural resources like soil properties. The sustainability of the yield becomes more important than simple mean yields, which also indicate the influence of particular management practice/treatment. Hence, SYI was calculated for different treatments by taking yield as dependent variable on different management practices with the following equation (Sharma *et al.,* 2004).

$$SYI = \frac{i - \sigma}{Y_{max}}$$

Where,

i = Average yield of the treatment.

σ = Treatment standard deviation.

Y_{max} = Maximum yield in the experiment over the years.

RESULTS AND DISCUSSION

Grain yield

The data pertaining to grain yield of rice during *rabi* 2014-15 and *kharif* 2015-16 are presented in Table1. The grain yield of rice ranged from 21.84 to 63.82 q ha^{-1} in *rabi* and 24.15 to 60.90 q ha^{-1} in *kharif*.

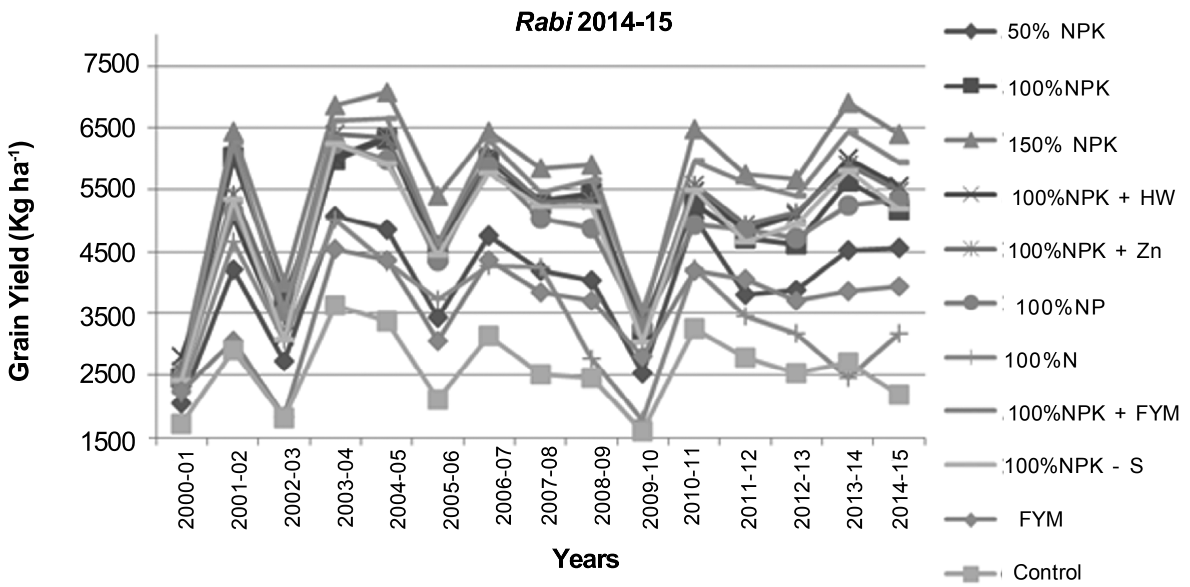

Fig.1: Effect of long term fertilizer and manure application on yield during *rabi* season (kg ha^{-1})

Table 1: Effect of long term fertilizer and manure application on rice grain yield and straw yield (q ha^{-1})

Treatment	Grain yield		Straw yield	
	Rabi 2014-15	*Kharif* 2015-16	*Rabi* 2014- 15	*Kharif* 2015-16
50% NPK	45.52	43.35	47.47	45.93
100%NPK	51.70	55.09	52.99	57.51
150% NPK	63.82	60.90	65.79	62.85
100%NPK + HW	55.48	57.78	56.83	59.55
100%NPK + Zn	54.80	57.61	56.76	59.77
100%NP	53.34	53.46	55.54	55.59
100%N	31.75	39.06	33.35	41.20
100%NPK + FYM	59.36	58.24	61.40	60.00
100%NPK - S	51.83	54.41	53.56	54.74
FYM	39.42	47.22	41.45	49.15
Control	21.84	24.15	23.89	25.51
S. Em. $\pm$	2.85	2.24	2.85	2.40
CD (5%)	8.27	6.51	8.27	6.97
CV (%)	11.84	8.96	11.42	9.24

The highest yield was recorded with the application of 150% NPK in both the seasons (63.821 and 60.90 q ha^{-1} in *rabi* and *kharif,* respectively). Application of 100% NPK along with FYM (@ 10 t ha^{-1}) resulted in 59.36 and 58.24 q ha^{-1} in *rabi* and *kharif* but slightly lower grain yield over 150% NPK. As FYM directly adds appreciable amounts of macro and micro nutrient, it plays a significant positive role in improving the soil environment. Similar results were also reported by Verma *et al.* (2012) and Selvi *et al.* (2005).

Increasing levels of NPK fertilizers significantly increased the grain yield over low doses. Application of optimum dose of NPK (120-60-40 kg ha^{-1}) exhibited beneficial effects over control and 50% NPK. An additional increase of NPK resulted in further increase in yield.

Among the fertilizer treatments, grain yield increased by 108.43 and 79.50%, with 50% NPK, 136.72 and 128.12% with 100% NPK, 192.22 and 152.17% with 150% NPK over control during *rabi* and *kharif,* respectively. Swarup (1998) while reviewing the yield trends of Long Term Fertilizer Experiments stated that crop yields show decline when input levels are kept constant and there is a need for application of higher doses of fertilizers to obtain same yield under continuous intensive cropping system.

Continuous application of only nitrogen every year resulted in reduced yields compared to 100% NP (68 and 36.87 per cent in *rabi* and *kharif,* respectively) and 100% NPK (62.83 and 41.04 per cent in *rabi* and *kharif,* respectively) emphasizing the need of balanced fertilization .

The data pertaining to straw yield of rice during 2014-15 and 2015-16 are presented in Table 1. The straw yield of rice ranged from 23.89 to 65.79 q ha^{-1} in *rabi* and 25.51 to 62.85 q ha^{-1} in *Kharif*. During *rabi* T_3-150% NPK (65.79 q ha^{-1}) recorded significantly higher straw yield over T_{11}, T_{10}, T_9, T_2, T_6 and T_1. However, T_3 recorded on par straw yield with that of T_8. Similarly, during *Khaif* T_3-150% NPK (62.85 q ha^{-1}) recorded significantly higher straw yield over T_{11}, T_{10}, T_9, T_2, T_6 and T_1. However, T_3 recorded comparable straw yield with that of T_8.

In general application of 150% NPK and 100% NPK +FYM recorded higher yields (grain and straw) as compared to all other treatments which could be due to higher nutrient uptake and improvement of soil environment (Krishna *et al.* 2007 and Humne *et al.,* 2008a) and FYM proved to be beneficial in enhancing crop productivity and soil fertility (Khambalkar *et al.,* 2012) due to the indirect effect resulting from reduced loss of organically supplied nutrients. Better supply of nutrients through incorporation of organic manures is ascribed to congenial physical environment leading to better root activity and higher nutrient absorption, which results in higher yield (Thakur and Sawarkar, 2009). Decomposition of organic manures is accompanied by the release of appreciable amount of plant nutrients which could contribute towards the higher yields (Laxminarayana and Patiram, 2006).

Thakur *et al.* (2011) also reported that in continuous cropping, application of FYM along with optimal dose of 100% NPK was beneficial for enhanced crop productivity and soil fertility. Humne *et al.* (2008.b) opined that application of FYM increases nutrient uptake by improving the soil environment. Similar results were also reported by Verma *et al.* (2012)b, Selvi *et al. (*2005)b, Khambalkar *et al.* (2012)b.

Sustainable Yield Index of Treatments

The data pertaining to SYI have been presented in Table 2. From the viewpoint of SYI values, 100% NPK+FYM (T9) was superior with maximum SYI of 0.617 and 0.615 during *rabi* and *Kharif* seasons respectively.

Sustainable yield index (SYI) is a measure of yield sustainability of the crop over years. The SYI for the *rabi* and *kharif* rice was calculated by using the yield data for the last sixteen years following the procedure of Singh et al. (1990). Results (Table 2) showed that the SYI of *rabi* rice varied from 0.508 to 0.617. The relative order of SYI for different treatments was as follows 100% NPK+FYM, 150% NPK, FYM, 100% NPK+Zn, 100% NPK =100% NPK+HW and 50% NPK > 100% NP >100% NPK-S > control > 100% N. The results, therefore, showed that the highest value was associated with INM (100% NPK+FYM) treatment and the lowest value was with imbalanced fertilisation (100% N treatment). The results also revealed that the yield of *rabi* rice was more sustainable with application of 100% NPK+FYM treatment followed by 150% NPK fertiliser *i.e.* balanced fertiliser application along with organic manures or super optimal dose of NPK (T3) than the imbalanced fertilisation *i.e.* either with only nitrogenous fertiliser (T7) or combination of nitrogenous and phosphatic fertiliser (T6).

Results (Table 2 and Figure 3) showed that the SYI of *kharif* rice varied from 0.564 to 0.615. The relative order of SYI for different treatments is 100% NPK+FYM >150% NPK > 100% NPK-S > 100% NPK+Zn > 100% NPK > FYM > 100% NPK+HW >100% NP > 50% NPK > 100% N> control. The results of the study showed that the highest yield sustainability was associated with 100% NPK+FYM treatment and the lowest was with the only N application and control treatment. The results revealed that the yield of *kharif* rice is more sustainable with INM (100% NPK+FYM) treatment followed by balanced fertilisation with 150% NPK and least sustainable with the imbalanced fertilisation or without fertilisation.

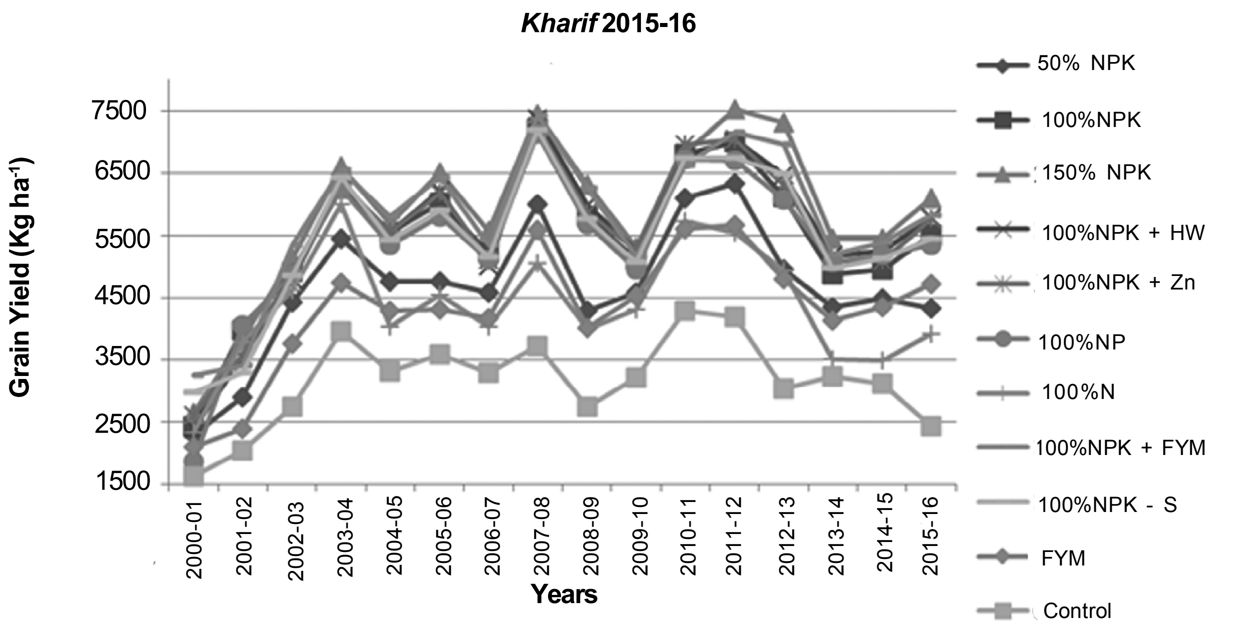

Fig. 2: Effect of long term fertilizer and manure application on yield during *kharif* (kg ha^{-1})

So, from the overall results it can be concluded that the addition of FYM with NPK fertiliser would be effective not only to increase the soil quality but also to sustain higher yields under rice-rice cropping system.

Table 2. Average yield (Kg ha^{-1}) and sustainable yield index (SYI) of rice from 2000-01 to 2015-16

	Grain				
	**Rabi*		***Kharif*		
	Average yield	SYI	Average yield	SYI	Overall SYI
50% NPK	3974	0.601	4658	0.571	0.59
100%NPK	4948	0.608	5481	0.595	0.60
150% NPK	5676	0.615	5853	0.605	0.61
100%NPK + HW	4967	0.608	5553	0.582	0.60
100%NPK + Zn	5039	0.609	5550	0.596	0.60
100%NP	4786	0.600	5384	0.582	0.59
100%N	3502	0.508	4358	0.571	0.54
100%NPK + FYM	5363	0.617	5754	0.615	0.62
100%NPK - S	4848	0.595	5470	0.598	0.60
FYM	3571	0.610	4319	0.586	0.60
Control	2581	0.542	3153	0.564	0.55

*. Average yield (Kg ha^{-1}) and sustainable yield index (SYI) of rice from 2000-01 to 2014-15.
**. Average yield (Kg ha^{-1}) and sustainable yield index (SYI) of rice from 2000-01 to 2015-16.

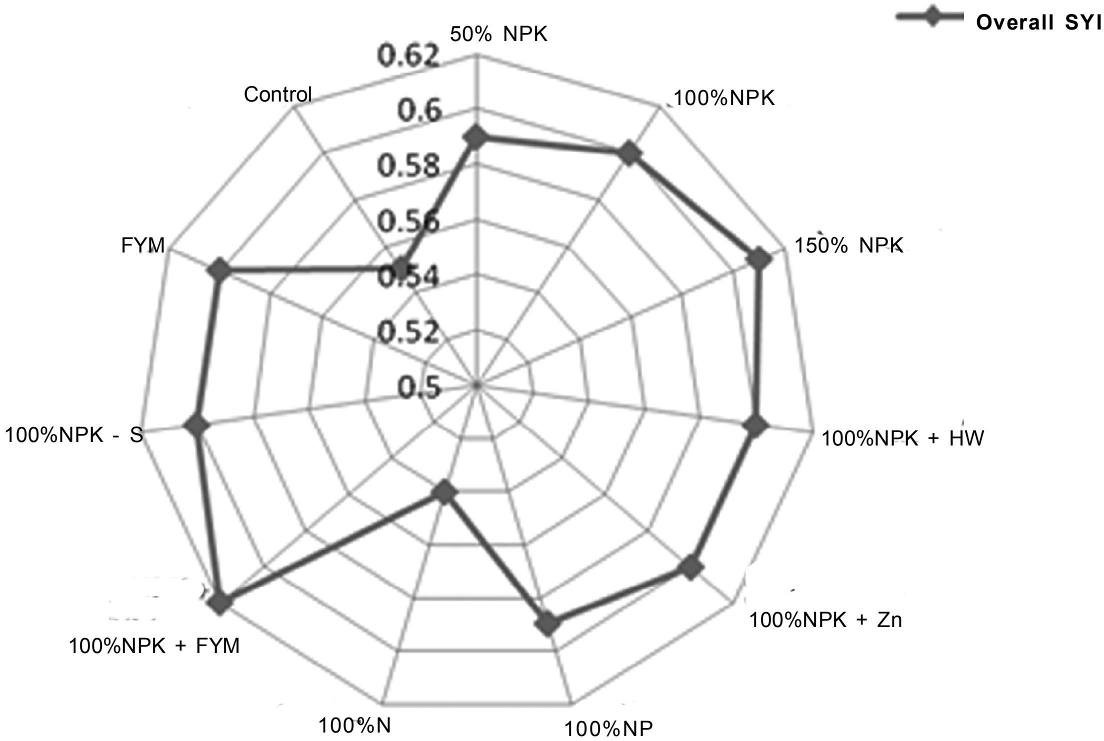

Fig. 3: Effect of long term fertilizer and manure application on overall SYI

Conclusion

Yields of rice under the long-term (16 years) experiment at Jagtial, Telangana, declined with imbalanced application of fertilizers (only N fertilizers) or without fertilizers (control). However, yields and soil fertility markedly improved when recommended doses of NPK were applied along with FYM. Addition of FYM with NPK fertilizers increased SOC and total soil N over NPK alone treatment.

The application of recommended dose of fertilizers along with organic manure was found to be a viable option for restoring soil organic carbon and nutrient turnover, thereby improving the availability of nutrients in soil, maintaining soil quality, and helping to achieve sustainable productivity of rice -rice system for the long run under irrigated moisture regimes. Continuous imbalanced application can markedly reduce the yield sustainability. Therefore, judicious application of inorganic and organic nutrients in an integrated manner is essential for sustaining crop productivity in a long-term.

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Research Article
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GRAIN PROTEIN FRACTIONS OF INDIAN RICE VARIETIES

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ABSTRACT

Rice is one of the world's cereal staple and an important crop in Asia. Rice protein is a second dominant principal nutrient and the sole protein source for underprivileged people. Based on Osborn classification of solubility, protein fractions are classified into glutelins, albumins, globulins and prolamins and their solubility in alkali, water, salt and alcohol respectively. The present investigation is focused on assessing total protein and protein fractions. The protein fractions and total protein were isolated by specific extraction buffers from rice flour and quantified by Lowry method. The selected varieties for this study showed the range of total protein albumin, globulin, prolamin and glutelin from 4.95% (Vibhava) to 6.52% (BPT5204) and on par with Ravi (6.09%); 0.03% (Rasi) to 0.54% (Vibhava); 0.02% (Sampada) to 0.07% (Vibhava); 0.28% (Sampada) to 0.82% (Rasi); and 0.16% (Rasi) to 0.61% (BPT5204) respectively. Among varieties total protein, albumin and globulin were statistically significant and prolamin and glutelin are found to be non-significant at $p<5\%$. In silico analysis of rice protein fractions explains the quality of rice protein in terms with essential amino acid score and molecular weight. This study concludes the information of protein fractions in above rice varieties.

Rice is one of the world's cereal staple and an important crop in Asia. The cooking and eating characteristics of rice starch are controlled by the rice starch source, genotype and amylose to amylopectin ratio, gelatinization temperature and gel consistency. Short term as well as long term storage affects rice pasting as well as cooking and eating characteristics but, comparatively, the long term storage has significant effect (Perdon, *et al.,* 1997). Eating qualities of rice grains and flour in processing industry are mainly attributable to starch composition and rice storage proteins. Protein fractions in rice have an impact on the texture to some degree, particularly the tenderness and cohesiveness of cooked rice (Ramesh, *et al.,* 2000). Rice protein is a second dominant principal nutrient and the sole protein source for underprivileged people. Rice grain protein fractions are classified into glutelins, albumins, globulins and prolamins based on their solubility in alkali, water, salt and alcohol respectively (Osborn, 1924).

Protein in rice is mainly located in the endosperm (Agboola and Mills, 2005; Borght *et al.,* 2006) and accounts for 6% in polished rice. Glutelin is a seed protein fraction accounts for 20% of the grain. Globulin and albumin are considered as rice allergenic proteins which account for 5-10% each and prolamin accounts for 20%. Studies have shown that these albumins are potentially allergenic for patients with rice allergy (Matsuda, *et al.,* 1988; Urisu, *et al.,* 1991). A major component of globulin called á-globulin is also one of the major allergenic proteins in rice (Limas, *et al.,* 1990). However, in Indian context, allergy reports on rice consumption are rare and rice is considered as the first food for infants.

The functional properties of rice grains and flours are determined by the glutelin fraction, called oryzenin, through disulfide bonds (Martin and Fitzgerald, 2002; Tulyathan and Leeharatanaluk, 2007). The formation of disulfide bonds restricts the expansion of the starch fraction during gelatinization. Increasing or decreasing the disulfide bond content was reported to alter the pasting properties and textural structure of rice grains and flour (Derycke, *et al.,* 2005; Hamaker and Griffin, 1993).

Protein quantity and quality rely on cultivation conditions and presently, emphasis is on quality which in turn influence nutritional, textural and functional aspects of rice. Having small genome, rice is a model plant for proteomic studies. Considering the essentiality to identify and catalogue rice grain proteins, this study was attempted to quantify the actual total protein and its fractions in selective rice samples. In addition, in silico amino acid composition analysis was performed to know the nutritional status of the various categories of rice grain proteins.

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MATERIALS AND METHODS

The harvested grain of 5 selected rice varieties cultivated in Indian Institute of Rice Research (IIRR) experimental fields following standard package of practices were dried and stored for three months. The paddy samples were shelled in the Rice Sheller (Satake TH4 (No. 1012077) then polished in polisher made of Satake TM05C (No. 554456) and made to a fine powder with mortar and pestle.

Estimation of total protein and protein fractions

The extraction buffers were used to isolate protein and protein fractions. For the total protein 50mM TrisHCl (pH 7.5), 2%SDS, 0.6% 2-mercaptoethanol, 20% Glycerol, 4M Urea (Lang, *et al.,* 2013), and protein fractions: albumin 500iL of 10mM Tris HCl solution (pH 7.5) and 1mM EDTA (Santos *et al.,* 2013); globulin 10mM TrisHCl (pH 7.5), 1mMEDTA & 0.5 mL NaCl (Santos *et al.,* 2013); prolamin Isopropanol 60% (Santos *et al.,* 2013) and glutelin 50mmol TrisHCl (pH 6.8), 4% SDS, 5% 2-mercaptoethanol, 20% Glycerol, 8M Urea (Kawakatsu *et al.,* 2008) were used.

The isolated total protein and protein fractions were quantified by Lowry method (Lowry, *et al.,* 1951) using Bovine Serum Album (BSA) as standard ($y = 0.002x + 0.006$, $R^2 = 0.999$).

All experiments were carried out in triplicates and data were reported as mean ± standard deviation. The differences of mean values among selected rice varieties were determined by one way analysis of variance (ANOVA) by using Web Agri Stat Package WASP 1.0.

In silico amino acid composition estimation

Protein sequences of albumin, globulin, prolamin and glutelin were downloaded in FASTA format from the non-redundant database of NCBI on 06.03.2019. Under each protein fractions albumin, globulin, prolamin and glutelin the number of sequences were found as 3, 79, 201 and 210 respectively. The downloaded sequences were copied into text files (.txt) and each file was processed in BioEdit sequence alignment editor (version 7.2.5) software using protein sequence composition tool (Hall, 1999).

RESULTS AND DISCUSSION

The protein fractions - albumin globulin, prolamin, glutelin and total protein in the five varieties are presented in Table 1. The total protein ranged from 4.95% (Vibhava) to 6.52% (BPT5204). The range of protein fractions *i.e.,* albumin, globulin, prolamin and glutelin are 0.03% (Rasi) to 0.54% (Vibhava), 0.02% (Sampada) to 0.07% (Vibhava), 0.28% (Sampada) to 0.82% (Rasi), and 0.16% (Rasi) to 0.61% (BPT5204) respectively. The albumin (CD 0.149), globulin (CD 0.007) and total protein (CD 0.748) were statistically significant among varieties ($p<5\%$). Prolamin and glutelin were non-significant among varieties at $p<5\%$.

Table 1 : Total protein and protein fractions of rice varieties

Name of the cultivar	Albumin (%)	Globulin (%)	Prolamin (%)	Glutelin (%)	Total protein (%)
Vibhava	0.54±0.15[a]	0.072±0.03[a]	0.72±0.89	0.54±0.05	4.95±0.37[c]
Ravi	0.38±0.06[b]	0.051±0.006[b]	0.36±0.01	0.45±0.19	6.09±0.74[ab]
BPT 5204	0.14±0.07[c]	0.025±0.004[d]	0.81±0.37	0.61±0.40	6.52±0.07[a]
Sampada	0.12±0.03[c]	0.023±0.002[d]	0.28±0.01	0.36±0.17	5.25±0.23[c]
Rasi	0.03±0.003[c]	0.033±0.002[c]	0.82±0.37	0.16±0.09	5.48±0.312[c]
CD (0.05)	0.149	0.007	NS	NS	0.748

NS-non significant

The cumulative values of protein fractions were found to be much lesser than the total protein content. This suggests either the buffers recommended for the protein fraction categories are unable to extract all the proteins of that fraction or more fractions of protein other than mentioned might be available. Albumin and globulin protein fractions are considered generally as allergic proteins and rice varieties having lesser amount of these fractions are friendly for rice protein sensitive individuals.

In the present study rice flour proteins were estimated in defatted rice flour and the supernatants, and freeze-dried protein products were determined by the Kjeldahl method, and the nitrogen content was multiplied by 5.95. Albumin, globulin, and glutelin were precipitated from their supernatants by adjusting pH to their isoelectric points. The rice flour (long grain, RL 100) contained 8.8% total protein. The total protein contained 0.38% albumin, 1.12% globulin, 6.81% glutelin, and 0.21% prolamin (Ju, *et al.,* 2001).

Albumins showed 16-18 bands (Padhye and Salunkhe, 1979) with molecular weight ranging from 10 to 200 kDa (Iwasaki *et al.,* 1982). Globulins showed 9 bands (Padhye & Salunkhe, 1979) with molecular weight raging from 10 to 150 kDa (Hamada, 1997). Glutelin showed 12 bands by Pandhye and Salunkhe (1979), 21 bands by Wen and Luthe (1985), 14 bands with molecular weight of 22kDa to 33 kDa by Zarins and Chrastil (1992) in rice. Prolamin showed 5 bands by Padhye & Salunkhe (1979) and molecular weight of prolamin ranged from 10-16 kDa (Hibino *et al.,* 1989; Ogawa *et al.,* 1987). Gang-hua, *et al.,* 2013 indicated that total rice protein varies from 4.5 to 15.9%. They used four different buffers to extract total protein and reported that highest yield of total protein using 50mM TrisHCl (pH 7.5), 2%SDS, 0.6% 2-mercaptoethanol, 20% Glycerol, 4M Urea (Lang, *et al.,* 2013) which was used in this current investigation.

In silico analysis of rice protein fractions-amino acid score

Access to sufficient quality food to maintain normal body composition and function throughout the life-cycle is fundamental in maintaining health. A source of protein is an essential element of a healthy diet, allowing both growth and maintenance of the 25000 proteins encoded within the human genome, as well as other nitrogenous compounds, which together form the body's dynamic system of structural and functional elements that exchange nitrogen with the environment.

Amino acids are required for the synthesis of body protein and other important nitrogen-containing compounds, such as creatine, peptide hormones, and some neurotransmitters. Although allowances are expressed as protein, the biological requirement is for amino acids. Both animal and plant proteins are made up of about 20 common amino acids. The proportion of these amino acids varies among proteins. Amino nitrogen accounts for approximately 16% of the weight of proteins. The amino acids—histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, arginine, and valine are not synthesized by mammals and are therefore essential in dietary intake or indispensable nutrients. These are commonly called the essential amino acids (Robert Murray *et al.,* 2003). The physiological roles of essential amino acids are presented in Table 2.

Table 2 : Essential amino acids and their roles

Essential amino acid	Role
Isoleucine	Formation of heamoglobin; prevents muscle wasting in debilitated individuals
Leucine	Promotes healing skin and boken bones; reduces muscle protein breakdown
Valine	Influences brian uptake of other neurotransmitter precusrsors (tryptophan, phyenylalanine and tyrosine)
Histidine	Production of red and white blood cells; treatment of anemia
Lysine	Inhibits viruses; treatment of herpes simplex, Lysine and Vitamin C together form L-carnitine, a biochemical that enables muscle tissue to use oxygen more efficiently delaying fatigue
Methionine	Increases the antioxidant levels (glutathione); reduces blood cholesterol levels
Phenylalanine	Production of collagen, precursor of tyrosine; enhances learning, memory, mood and alertness
Threonine	Prevents fatty build up in the liver; amino detoxifers
Tryptophan	Prevents fatty buildup in the liver; precursor of key neurotransmitter serotonin, which excerts a calming effect
Arginine	Functioning of urea cycle

As rice feeds more than half of the world's population and it contains around 6-15% of total protein content, it is essential to know the amino acid composition of rice. Although, the amino acid sequences of rice grain proteins are reported in India, studies on protein were mostly confined to total protein content. And very few reports are available on various classes of proteins. *Oryza sativa* have three sub species called *Oryza sativa Indica, Oryza sativa Japonica,* and *Oryza sativa Javonica*. Among these, most of the downloaded sequences were *japonica* and very few available on the remaining rice species. In India, most of the cultivated rice varieties are descended from *Indica* germplasm. In this context, in silico analysis was carried out to know the amino acid score of the rice protein fractions.

Rice (*Oryza Indica*) albumin protein sequence was available (Table 3) with a total amino acid of 823 amino acids and the essential amino acid score is 422 and molecular per cent with 51.27. Rice globulin sequence was with a total amino acid score of 155 in *indica* and 383.4 in *sativa,* the essential amino acid score is 70 (*indica*) and 176.0 (*japonica*) and molecular per cent with 44.82 and 44.73 in *indica* and *japonica* species respectively. Prolamin fraction rice grain protein sequence was with a total amino acid score 237.0 and 152.73, the essential amino acid score are 100.0 and 63.55 and essential amino acid molecular per cent with 41.5 & 41.65 in *sativa and japonica* respectively. Table 3 also presents the rice glutelin protein sequence with a total amino acid score 499.56, 474.0 and 474.17, the essential amino acid score are 216.44, 216 & 205.83 and essential amino acid molecular per cent with 43.32, 45.57 and 43.39 in *sativa, japonica* and *indica* respectively. The detailed information on amino acid scores of rice protein fractions were compiled in Table 4, 5 and 6.

As there is variation in the total protein content and its classes among the five varieties, it appears essential to screen the same in more number of released varieties and various germplasm to know the diversity of total protein content as well as the four categories. If the diversity is significant like zinc content, then there will be scope for developing new rice lines with better protein content in quantity or quality or in both.

Table 3 : Rice protein fractions amino acid score

Protein category	Sub-species	No. of sequences	Total amino acid score	Essential amino acid score	Essential amino acid Mol%
Albumin	*Indica*	1	823	422	51.27
Globulin	*Indica*	2	155	70	44.82
	Japonica	10	383.4	176.0	44.73
Prolamin	*Sativa*	4	237.0	100.0	41.5
	Japonica	11	152.73	63.55	41.65
Glutelin	*Sativa*	9	499.56	216.44	43.32
	Japonica	2	474.0	216	45.57
	Indica	6	474.17	205.83	43.39

Table 4 : Amino acid scores of rice albumin and globulin

Amino Acid	Albumin	Globulin													
	O.s.indica	*O. s. indica*			*O. s.japonica*										
	EEC66529.1	AAC32819.1	AAC32820.1	Mean	XP_015639142.1 19	XP_015611195.1	XP_015638147.1	XP_015637530.1	XP_015637529.1	XP_015649493.1	XP_015645797.1	XP_015641111.1 11S	XP_015640214.1	CAA45400.1 19	Mean
Ala	55	19	8	13.5	17	63	50	46	52	55	42	36	48	17	42.60
Cys	19	1	3	2	8	13	13	13	14	10	14	6	14	8	11.30
Asp	42	8	6	7	5	18	20	16	16	14	19	20	21	5	15.40
Glu	64	12	15	13.5	16	14	11	13	11	7	12	18	14	16	13.20
Phe	26	2	7	4.5	6	17	21	23	24	23	21	19	20	6	18.00
Gly	46	16	15	15.5	15	36	42	44	39	37	41	36	40	15	34.50
His	19	2	4	3	0	7	4	3	4	4	5	5	3	1	3.60
Ile	57	8	5	6.5	3	8	13	14	10	13	13	17	12	3	10.60
Lys	49	8	7	7.5	1	10	20	11	16	9	10	16	11	1	10.50
Leu	96	15	11	13	11	46	46	48	48	41	44	35	47	10	37.60
Met	15	8	0	4	11	9	8	7	9	7	13	10	10	11	9.50
Asn	31	12	5	8.5	0	7	11	13	12	17	14	11	11	0	9.60
Pro	40	7	7	7	8	32	31	36	34	26	39	21	35	8	27.00
Gln	25	3	6	4.5	22	8	12	8	10	10	11	9	8	21	11.90
Arg	50	18	13	15.5	21	27	20	27	19	22	23	17	24	21	22.10
Ser	63	10	13	11.5	20	41	34	32	40	37	32	34	28	20	31.80
Thr	41	7	6	6.5	3	29	42	41	43	32	33	24	36	3	28.60
Val	60	14	3	8.5	9	48	43	41	45	28	34	31	32	10	32.10
Trp	9	1	1	1	1	2	3	2	2	2	8	6	7	1	3.40
Tyr	16	3	1	2	9	9	11	14	8	8	14	6	13	9	10.10
Total AA	823	174	136	155	186	444	455	452	456	402	442	377	434	186	383.40
EAA	422	83	57	70	66	203	220	217	220	181	204	180	202	67	176.00

Table 5 : Amino acid scores of rice prolamin

AA	Prolamin																
	O. s.japonica												*Oryza sativa*				
	AAA50319.1	AAF73991.1	CAA46197.1	CAA37850.1	CAA37849.1	ATS17258.1	CAA43295.1	ABL74542.1	ABL74540.1	ABL74539.1	ABL74538.1	Mean	AGT59176.1	BAA36699.1	BAA36698.1	BAA36697.1	Mean
Ala	14	16	14	17	16	18	16	18	17	18	18	16.55	30	17	19	16	20.5
Cys	11	5	5	1	1	1	5	8	9	9	9	5.82	10	9	1	5	6.3
Asp	1	2	2	4	4	5	2	2	2	2	2	2.55	22	2	4	2	7.5
Glu	0	1	1	1	1	1	2	1	1	1	1	1.00	22	1	1	1	6.3
Phe	5	7	9	9	8	7	7	11	10	10	10	8.45	21	10	9	7	11.8
Gly	8	4	4	7	6	6	4	5	4	5	5	5.27	35	4	7	4	12.5
His	1	3	2	2	2	2	3	2	2	2	1	2.00	13	2	1	3	4.8
Ile	4	11	11	9	10	10	11	10	10	10	10	9.64	23	10	9	11	13.3
Lys	2	1	1	1	1	2	1	1	1	1	1	1.18	14	1	1	1	4.3
Leu	10	17	16	20	22	23	17	13	12	13	15	16.18	40	12	19	17	22.0
Met	23	2	2	1	1	1	2	6	7	6	6	5.18	4	7	1	2	3.5
Asn	2	5	5	6	7	6	5	3	3	3	3	4.36	29	3	6	5	10.8
Pro	7	7	7	7	5	6	7	7	8	7	8	6.91	20	8	6	7	10.3
Gln	19	30	30	25	25	26	31	31	30	31	31	28.09	51	30	26	30	34.3
Arg	1	5	5	7	8	6	5	5	5	5	4	5.09	36	5	6	5	13.0
Ser	10	12	13	8	8	12	13	11	13	11	11	11.09	37	13	10	12	18.0
Thr	10	4	6	3	4	2	5	5	5	5	5	4.91	19	5	3	4	7.8
Val	2	14	12	10	11	7	14	10	10	10	9	9.91	38	10	10	14	18.0
Trp	0	2	2	1	0	1	1	1	1	1	1	1.00	3	1	1	2	1.8
Tyr	4	8	9	10	10	11	7	6	6	6	6	7.55	19	6	10	8	10.8
Total AA	134	156	156	149	150	153	158	156	156	156	156	152.73	486	156	150	156	237.0
EAA	58	66	66	63	67	61	66	64	63	63	62	63.55	211	63	60	66	100.0

Table 6 : Amino acid scores of rice glutelin

A A	Glutelin																		
	Oryza sativa										*O. s. japonica*			*O. s. indica*					
	CAA38110.1	CAA38212.1	CAA38211.1	CAA29152.1	CAA29151.1	CAA29149.1	AAA33906.1	CAA68683.1	BAA36695.1	Mean	AFZ41188.1	AFZ41190.1	Mean	AGT59174.1	AGT59175.1	AFZ41187.1	AGT59179.1	AGT59178.1	AGT59177.1	Mean
Ala	36	33	31	32	32	34	32	32	43	33.89	27	36	31.50	33	30	26	39	35	34	32.83
Cys	7	7	10	10	10	10	10	10	6	8.89	5	7	6.00	8	8	5	7	7	7	7.00
Asp	12	12	22	16	16	15	15	16	18	15.78	12	17	14.50	15	15	12	15	12	12	13.50
Glu	25	27	22	26	26	27	27	26	26	25.78	27	25	26.00	26	26	27	26	28	23	26.00
Phe	30	28	24	24	24	23	23	24	26	25.11	23	25	24.00	20	21	21	25	28	28	23.83
Gly	32	33	35	37	37	36	35	37	34	35.11	35	33	34.00	32	34	36	33	33	33	33.50
His	11	12	13	10	10	9	9	10	16	11.11	12	13	12.50	10	10	12	12	11	11	11.00
Ile	26	26	25	24	24	23	21	24	23	24.00	33	29	31.00	21	22	31	30	24	24	25.33
Lys	17	16	15	12	12	12	12	12	15	13.67	20	17	18.50	13	12	19	17	15	16	15.33
Leu	34	35	41	38	38	39	39	38	43	38.33	39	37	38.00	32	32	41	36	35	35	35.17
Met	7	6	5	5	5	3	3	5	10	5.44	5	1	3.00	3	4	5	2	6	5	4.17
Asn	35	35	29	34	34	34	33	34	27	32.78	45	31	38.00	33	33	45	32	35	35	35.50
Pro	21	22	20	22	22	21	20	22	25	21.67	23	21	22.00	19	20	23	23	22	22	21.50
Gln	54	54	51	52	52	54	54	52	48	52.33	46	46	46.00	48	47	44	46	55	55	49.17
Arg	32	35	36	38	38	40	41	38	35	37.00	36	37	36.50	35	35	36	37	34	34	35.17
Ser	39	40	36	38	38	40	42	38	38	38.78	24	24	24.00	33	31	24	21	41	37	31.17
Thr	19	18	20	21	21	20	21	21	20	20.11	21	15	18.00	18	19	22	16	18	17	18.33
Val	36	37	39	37	37	37	40	37	40	37.78	29	33	31.00	34	35	32	31	37	37	34.33
Trp	4	4	3	4	4	3	3	4	6	3.89	3	4	3.50	2	3	3	3	4	4	3.17
Tyr	19	19	19	19	19	19	19	19	11	18.11	15	17	16.00	19	19	16	17	19	19	18.17
Total AA	496	499	496	499	499	499	499	499	510	499.56	480	468	474.00	454	456	480	468	499	488	474.17
EAA	216	217	221	213	213	209	212	213	234	216.44	221	211	216.00	188	193	222	209	212	211	205.83

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Research Article
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AN ANALYSIS OF PLANT NURSERY BUSINESS AND PRODUCTION RESOURCES IN TWIN CITIES OF TELANGANA

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ABSTRACT

Plant nursery sector is playing an important role in the country after agriculture in providing self-employment to the youth. It also contributes in protection of the environment. The purpose of the study was to gather information regarding plant nurseries. A total number of 25 plant nurseries were selected through purposive random sampling technique. Data was analyzed by using Microsoft Excel 2010. Frequencies and percentage were performed to detect the statistical significance. Results revealed that majority (40%) of the plant nurseries were forestry developed under open spaces (56%) by taking a rented land (48%) within 0.51-1.0 hectares of land and engaged both wife and husband (60%) in different activities of plant nursery. Nearly half percentage of plant nurseries were using polythene bag method and inorganic manure for the growth and development of seedlings. Forty per cent of the sampled nurseries were private established by taking loans from bank and from government sponsors, providing gardening services and sales were done through contract.

Plant nurseries have been an emerging interest in small-scale or small holder enterprise. Small scale enterprises certainly play an important role in the production of goods and services and in generation of substantial employment and income in almost, both developing and developed countries.Now a days, plant nurseries are crucial success factors for many forestry and agricultural development programmes. A plant nursery is a managed and selected site to produce seedlings under favorable conditions until they are ready for final planting. It can be an informal set up, small scale arrangement or a large commercial enterprise and it varies in size, facilities (supplies, tools, equipment, etc.) types of seedlings produced, and type of activities performed in the nursery (James *et al.* 2010). Larinde and Santus (2014), found that plants raised in the nursery were ornamental, agricultural, horticultural, medicinal and forestry and also indicated that the services rendered by the nursery operators were seedling supply by 34.52 per cent, landscaping with a percentage of 32.74, maintenance of private gardens 30.97 per cent and other services like indoor/banqueting and indoor fumigation constituted by 1.77 per cent.Babalola (2008) revealed that most of the labour provided by the nursery operators were family members and some hired labourers. The seedlings of ornamental plants were in highest demand followed by seedlings of horticultural crops, and forest trees. It also revealed that the land used for establishing nurseries was took through lease from the government, some through purchase and some in the form of family land. Fakayode *et al.* (2008) in the study indicated that 59.25% of the owners of ornamental business established their nurseries in 0.01-0.50 hectare of land. Hence the research was carried out to study the general information about plant nurseries.

MATERIALS AND METHODS

Exploratory research design was selected for the study. A purposive random sampling technique was used to select plant nurseries. A total of 25 plant nurseries from twin cities of Telangana i.e., Hyderabad and Secunderabad were selected for the study. Variables selected for the study were analysis of production resources, methods and techniques used for raising seedlings and marketing. Interview schedule was used for data collection. Frequencies and percentages were used for analyzing the data by using Microsoft Excel 2010.

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RESULTS AND DISCUSSION

The results of the present study are presented below.

A total of 25 plant nurseries were selected for the study. The study was conducted mainly to assess the plant nursery business in terms of analysis of production resources, categories of seedling produced by plant nurseries and marketing of plant nurseries in the study area. Collected data regarding the assessment of the plant nursery business was tabulated, presented and discussed below in detail.

Based on the analysis of production resources, it was found that majority (40%) of the plant nurseries were forestry followed by mixed plant nursery (28%), vegetable plant nursery (20%), flower plant nursery (8%) and only 4 per cent were ornamental plant nursery (Table. 1).

With reference to the type of labour used for the management of plant nurseries, sixty per cent of the nurseries both wife and husband worked as labour and only 16 per cent of plant nurseries had hired the labour. Twenty four per cent of nurseries had used the services of both family and hired labour for managing the plant nurseries (Table 1).

Out of the total plant nurseries, maximum (48%) number of nurseries was developed under rented land while minimum (12%) number of nurseries were developed under leased land. Forty per cent of nurseries were developed in own land (Table 1).

Most of the nurseries (76%) were established in 0.51-1.0 hectare of land whereas 20 per cent of the nurseries were established in 0.01- 0.50 hectare of land. Only 4 per cent of nurseries were established in above one hectare of land (Table 1).

Table 1: Analysis of production resources

(n=25)

S.No	Variables	Frequency (N)	Percentage (%)
1.	**Type of plant nursery**		
	Vegetable plant nursery	5	20.00
	Forestry plant nursery	10	40.00
	Ornamental plant nursery	1	04.00
	Flower plant nursery	2	08.00
	Mixed plant nursery	7	28.00
2.	**Type of labour used for the management of plant nursery**		
	Hired	4	16.00
	Family	15	60.00
	Both	6	24.00
3.	**Source of land**		
	Owned land	10	40.00
	Rented land	12	48.00
	Leased land	3	12.00
4.	**Size/Area of nursery**		
	Small (0.01-0.50 ha.)	5	20.00
	Medium (0.51-1.0 ha.)	19	76.00
	Large (>1.0 ha.)	1	4.00
5.	**Years in the business**		
	Less than 8 years	2	8.00
	Between 9-14 years	17	68.00
	More than 15 years	6	24.00

With reference to the years in the business by sampled nurseries, highest percentage (68%) were established between 9-14 years back and lowest percentage (8%) of the nursery owners have established their business less than 8 years back. Twenty four per cent of the sampled nurseries were established more than 15 years back (Table 1).

As illustrated from the Table 2, highest (48%) number of plant nurseries were using polythene bag method and lowest (4%) number of nurseries were using earthen pot method. Equal percentages (24%) of plant nurseries were using land and plug-tray(pro-tray) method.

With reference to the type of techniques used in nursery for protection of seedlings/herbs/shrubs, more than half of the sampled nurseries (56%) were using an open area development technique, whereas less than half of the sampled nurseries (44 percent) were using an advanced technique i.e., green house or shaded net technique (Table 2).

Out of the total sampled nurseries, 44 per cent of the nurseries were using inorganic manure and solely dependent on organic manure (20 percent) while 36 per cent used both organic and inorganic fertilizer (Table 2).

The data from the table 3 depicted that, out of the total sampled nurseries majority (40%) of the sampled nurseries were private, followed by government nurseries (32%) and 28 per cent of semi-government nurseries.

With reference to the funding type of nursery, 20 per cent of the plant nurseries were developed by their personal savings whereas equal percentage (40%) of plant nurseries were developed by taking loans from bank and from government sponsors (Table 3).

Type of services rendered by sampled nurseries, gardening ranked the highest with 40 per cent of services whereas sales of potted plants ranked the lowest (12%) rendered services. Equal percentage (24%) of services were rendered in both landscaping and seedling supply (Table 3).

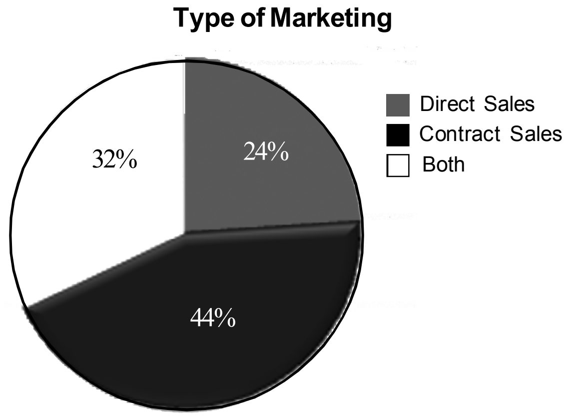

Figure 1 : Distribution of type of marketing

As illustrated in Fig.1, forty four per cent of the sales were done through contract and 24 per cent were done through direct sales.

Table 2 : Methods and techniques used for producing seedlings

(n=25)

S.No	Variables	Frequency (N)	Percentage (%)
1.	**Type of method used for raising seedlings**		
	Land method	6	24.00
	Earthen pot method	1	4.00
	Plug tray (Pro-Tray) method	6	24.00
	Polythene bag method	12	48.00
2.	**Type of techniques used in nursery for protection of seedlings/herbs/shrubs**		
	An open area development technique	14	56.00
	Advanced technique (Green house/Shade net)	11	44.00
3.	**Type of fertilizer used in nursery for raising seedlings**		
	Organic	5	20.00
	Inorganic	11	44.00
	Both	9	36.00

Table 3: Marketing of plant nursery in the study area

(n=25)

S.No	Variables	Frequency (N)	Percentage (%)
1.	**Type of nursery organization**		
	Government organization	8	32.00
	Private organization	10	40.00
	Semi-government organization	7	28.00
2.	**Funding type**		
	Personal savings	5	20.00
	Loans taken from bank	10	40.00
	Sponsored by government	10	40.00
3.	**Type of services rendered in plant nursery**		
	Landscaping	6	24.00
	Sales of potted plants	3	12.00
	Seedling supply	6	24.00
	Gardening	10	40.00

Conclusion

From the study, it was concluded that majority of the plant nurseries were forestry developed under open spaces by taking a rented land within 0.51-1.0 hectares of land and were engaged both wife and husband were engaged in different activities of plant nursery. Nearly 50 percent of plant nurseries were using polythene bag method and inorganic manure for the growth and development of seedlings. Majority of the sampled nurseries were private established by taking loans from bank and from government sponsors, providing gardening services and sales were done through contract.

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ECONOMIC ANALYSIS OF RED GRAM CULTIVATION IN GULBARGA DISTRICT OF KARNATAKA STATE

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Red gram, a major pulse crop commonly known as *Tur* or *Arhar* in India is the second important pulse in the country after gram (*chana*). The ability of red gram to produce high economic yields under soil moisture deficit makes it an important crop in rain fed and dry land agriculture.

Red gram accounts for about 11.8% of the total pulse area and 17% of the total pulse production of the country. In India, major red gram producing states are Maharashtra (12.72 lakh ha), Karnataka (8.79 lakh ha), Madhya Pradesh (6.51 lakh ha), Uttar Pradesh (3.36 lakh ha), Telangana (2.84 lakh ha), Gujarat (2.76 lakh ha) and Andhra Pradesh (2.24 lakh ha). In Karnataka this crop was cultivated in an area of 8.79 lakh hectares during 2017-18. The major red gram growing districts in Karnataka are Gulbarga, Bidar, Raichur and Vijayapura.

Gulbarga district in the state is leading in red gram production. The district is also called as "pulse bowl" of the state. For meeting the demand of the growing population, the country has imported red gram to the tune of 309.35 thousand tonnes in the year 2017-18 which accounts for 6.60 per cent of total pulse import in the country (https://data.gov.in, Ministry of agriculture and farmers welfare, 2018). In order to encourage the farmers towards red gram cultivation and increase its production there is need to analyze the profitability of its cultivation. Under these circumstances, the present study was undertaken with the specific objective to study the economics of red gram cultivation in Gulbarga district of Karnataka state.

A combination of purposive and random sampling techniques was used for selection of district, taluks, villages and farmers required for the study. A total of 80 red gram growers from 8 selected villages i.e., two from each of selected taluks that are leading in red gram cultivation were considered for present study. The required primary data on costs and returns of red gram cultivation was obtained through a pre tested schedule using interview method. The collected data was analyzed using simple conventional tabular analysis and percentages to arrive at valid conclusions.

Cost of cultivation of red gram

Cost of cultivation of red gram crop is the sum total of costs incurred on various inputs that are used and number of labourers utilized in different operations. The profitability of any enterprise depends upon income generating capacity and cost structure. In this study total costs are discussed under two categories *viz*., variable costs and fixed costs. Variable costs include expenses on labour employed for performing different cultural practices and expenses incurred on material inputs *viz*., seeds, FYM, fertilizers, plant protection chemicals, etc. The fixed costs include depreciation on working assets, interest on fixed capital, rental value of owned land and land revenue. The particulars of cost of cultivation of red gram are presented in Table 1.

The average total cost of cultivation per hectare of red gram was Rs. 46190.06, Rs. 47976.04, Rs. 48883.00, Rs. 47509.57 and Rs. 47693.23 on marginal, small, medium, large and pooled farms respectively. The proportion of variable and fixed costs in the total cost of cultivation accounts for 58.91 and 41.09 per cent on marginal, 57.94 and 42.06 per cent on small, 59.39 and 40.61 per cent on medium, 58.65 and 41.35 per cent on large and 58.55 and 41.45 per cent on pooled farms respectively.

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Table 1 : Cost of cultivation of red gram in Gulbarga district (Rupees per hectare)

S.No	Particulars	Marginal	Small	Medium	Large	Pooled
1.	**Operational costs**					
a.	Human labour	8941.50 (19.36)	8974.50 (18.71)	9808.50 (20.07)	8979.00 (18.90)	9135.00 (19.15)
b.	Bullock labour	3728 (8.07)	3784 (7.89)	3760 (7.69)	3760 (7.91)	3764 (7.89)
c.	Tractor power	3405 (7.37)	3535 (7.37)	3790 (7.75)	3415 (7.19)	3540 (7.42)
d.	Seed	607.2 (1.31)	598.2 (1.25)	648.6 (1.33)	643.2 (1.35)	616.2 (1.29)
e.	FYM	2110 (4.57)	2530 (5.27)	2380 (4.87)	2410 (5.07)	2390 (5.01)
f.	Fertilizers	2710.22 (5.87)	2823.04 (5.88)	2858.22 (5.85)	2801.46 (5.90)	2801.60 (5.87)
g.	Plant protection chemicals	3825.45 (8.28)	3629.52 (7.57)	3782.49 (7.74)	3925.52 (8.26)	3744.90 (7.85)
h.	Interest on working capital	1882.66 (4.08)	1921.07 (4.00)	2003.92 (4.10)	1932.47 (4.07)	1930.68 (4.05)
Total operational cost		27210.03 (58.91)	27795.33 (57.94)	29031.73 (59.39)	27866.65 (58.65)	27922.38 (58.55)
2.	**Fixed costs**					
a.	Land revenue	200 (0.43)	200 (0.42)	200 (0.41)	200 (0.42)	200 (0.42)
b.	Rental value of owned land	15675.97 (33.94)	16754.90 (34.92)	16435.09 (33.62)	16234.24 (34.17)	16376.62 (34.34)
c.	Depreciation	1378.60 (2.98)	1391.21 (2.90)	1411.84 (2.89)	1423.00 (3.00)	1396.88 (2.93)
d.	Interest on fixed capital	1725.46 (3.74)	1834.61 (3.82)	1804.70 (3.69)	1785.72 (3.76)	1797.35 (3.77)
Total fixed cost		18980.03 (41.09)	20180.71 (42.06)	19851.70 (40.61)	19642.92 (41.35)	19770.85 (41.45)
Total cost		46190.06	47976.00	48883.00	47509.57	47693.23

Note: Figures in parenthesis indicate percentage to the total

The variable costs mainly comprised of cost of human labour, bullock labour, tractor power, seeds, farm yard manure, fertilizers, plant protection chemicals and interest on working capital. Among the variable costs, human labour accounts maximum followed by bullock labour, plant protection chemicals, tractor power, fertilizers and FYM. The cost of human labour which was Rs. 8941.50, Rs. 8974.50, Rs. 9808.50, Rs. 8979.00 and Rs. 9135.00 on marginal, small, medium, large and pooled farms accounts for 19.36, 18.71, 20.07, 18.90 and 19.15 per cent to total cost of cultivation respectively.

The expenditure on human labour was higher because it is a labour intensive crop. The expenditure on bullock labour in marginal, small, medium, large and pooled farms accounts for 8.07, 7.89, 7.69, 7.91 and

7.89 per cent to total cost of cultivation respectively. Similar kind of trend in costs with regard to tractor power, plant protection chemicals and FYM was observed in different size categories of farms. The cost of plant protection chemicals, tractor power, fertilizers and FYM accounts for 7.85, 7.42, 5.87 and 5.01 per cent respectively on pooled farms. The expenditure on seed was found minimum (1.29 %) among different operational costs. The interest on working capital calculated @ 7 per cent amounts Rs. 1930.68 accounting for 4.05 per cent.

Among the fixed costs rental value of owned land accounts maximum followed by interest on fixed capital, depreciation and land revenue. The rental value of owned land was Rs. 15675.97, Rs. 16754.98, Rs. 16435.09, Rs. 16234.24 and Rs. 16376.62 on marginal, small, medium, large and pooled farms which accounts for 33.94, 34.92, 33.62, 34.17 and 34.34 per cent respectively.The interest on fixed capital was Rs. 1725.46, Rs. 1834.61, Rs. 1804.70, Rs. 1785.72 and Rs. 1797.35 which accounts for 3.74, 3.82, 3.69, 3.76 and 3.77 per cent respectively.

The amount of depreciation of working assets calculated using straight line method @ 10 per cent was Rs. 1378.60, Rs. 1391.21, Rs. 1411.87, Rs.1423.00 and Rs.1396.88 on marginal, small, medium, large and pooled farmers which accounts for 2.98, 2.90, 2.89, 3.00 and 2.93 per cent respectively. An amount of Rs. 200 was the fixed land revenue per hectare incurred by all size categories of famers. The total cost of cultivation of red gram was found maximum on medium size farms (Rs. 48883.43) and minimum on marginal farms (Rs. 46190.06) with Rs. 47693.23 on an average pooled sample farm. These results are in confirmity with the results of Rao *et.al.,* 2010 and Gulve *et.al.,*2009.

Returns from red gram cultivation

The returns per hectare of red gram cultivation are presented in Table 2. The estimated cost of production of each quintal on pooled red gram farm was Rs. 3846.23 which almost ranged same in all size category farms. The yield obtained by red gram growers per hectare was 12.11, 12.45, 12.68, 12.31 and 12.40 q on marginal, small, medium, large and pooled farmers respectively. The gross returns per hectare of red gram cultivation were Rs. 47229, Rs. 48555, Rs. 49452, Rs. 48009 and Rs. 48360 on marginal, small, medium, large and pooled farms respectively. The net returns obtained over costs were Rs. 1038.94, Rs. 578.96, Rs. 568.57, Rs. 499.43 and Rs. 666.77 on marginal, small, medium, large and pooled farms respectively. Accordingly, the return per rupee spent was observed 1.02 on marginal farms followed by 1.01 on all other category farms.The cost of production on pooled (Rs/q) maximum in large farms (Rs.3859.43), minimum in marginal farms (Rs. 3814.21) and on pooled farms (Rs. 3846.23). However, with the average market price received per quintal i.e., Rs. 3900. The results of Banerjee *et al.*, 2010 are in conformity with the results obtained in the present study.

Table 2 : Returns from red gram production

S.No	Particulars	Marginal (Rs ha^{-1})	Small (Rs ha^{-1})	Medium (Rs ha^{-1})	Large (Rs ha^{-1})	Pooled (Rs ha^{-1})
1	Total cost	46190.06	47976.04	48883.43	47509.57	47693.23
2	Yield in (Qtl ha^{-1})	12.11	12.45	12.68	12.31	12.40
3	Cost of production (Rs qtl^{-1})	3814.21	3853.50	3855.16	3859.43	3846.23
4	Market price	3900	3900	3900	3900	3900
5	Gross return	47229.00	48555.00	49452.00	48009.00	48360.00
6	Net return	1038.94	578.96	568.57	499.43	666.77
7	Returns per rupee spent	1.02	1.01	1.01	1.01	1.01

The foregoing analysis of the data indicated that the cost of cultivation of red gram was high in the study area. Hence, in order to realize more profits the farmers should reduce the cost of cultivation of red gram and adopt high yielding varieties.

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ANALYSIS OF GROWTH AND INSTABILITY OF JOWAR AREA AND PRODUCTION IN ANDHRA PRADESH

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Millets are group of small grained cereal food crops which are highly nutritious and are grown under marginal/low fertile soils with very low inputs such as fertilizers and pesticides. These crops largely contribute to food and nutritional security of the country. Most of millet crops are native of India and are popularly known as Nutri-cereals as they provide most of the nutrients required for normal functioning of human body. Further, the nutritional value of these crops offers much scope for development of value-added products in new health conscious consumer segments. Coarse cereals, namely sorghum, pearl millet and finger millet assume significance in the cropping pattern of dryland regions as they require little inputs and are more drought resistant compared to other competing crops (Breese, *et al.,* 2002). Among which jowar is the most important food and fodder crop of dry land agriculture of Andhra Pradesh. The crop is perennial in nature and possessing corn like leaves and bearing the grain in a compact cluster. Out of the total production of jowar in the nation, 52 % is from Maharashtra. Karnataka, Andhra Pradesh and Tamil Nadu. One more advantage of this crop is that it can be grown in both *Kharif* and *Rabi* seasons. Also, it can handle and grow on a wide range of soil types starting from fertile to fewer nutrient soils but an effective output largely depends on soil moisture, resistance and porosity. This crop was favoured due to its productivity and short growing season under dry, high-temperature conditions. However, the last few decades saw this crop losing area on account of declining demand due to change in food habits and due attention has been given to cereals and commercial crops cultivation in Andhra Pradesh, that resulted in drop in real prices vis-a vis other competing crops leading to erosion in relative profitability of this crop.

The study is based on Andhra Pradesh secondary data for the period 1966-67 to 2016-17 on area, production and productivity collected from various issues of statistical abstracts published by the Bureau of Economics and Statistics, Government of Andhra Pradesh. The data were analysed by using following techniques. Compound growth rates were estimated by fitting an exponential function of the following form for the three periods 1966-67 to 1986-87, 1987-2000, 2001-02 to 2016-17 and overall period 1966-67 to 2016-17 for Andhra Pradesh as well as districts covering 80 per cent area.

Computation of annual growth rates

$$Y_t = AB^t e$$

where:

Y_t is the variable for which growth is calculated at t^{th} period,

t is the time variable,

A is constant,

B is (1+r), 'r' is compound growth rate and 'e' is error term.

Transforming this to logarithmic form

$$\ln Y_t = \ln A + (\ln B)\, t + \varepsilon$$

Then CAGR calculated as:

CAGR (per cent) = [antilog (ln B) - 1] x 100

Measurement of instability- Cuddy-Della Valle Index (CDI)

The instability in area, production and productivity was estimated using Cuddy-Della Valle index (CDVI). CDVI was originally developed by John

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Cuddy and Della Valle for measuring the instability in time series data that is characterized by trend (Cuddy and Della Valle, 1978). The estimable form of the equation is as follows:

$$CDI = CVx\sqrt{1-R\wedge 2}$$

Where:

CDI = the instability index in percent,

CV = coefficient of variation in percent,

R^2 = coefficient of determination from time trend regression adjusted by the number of degrees of freedom.

Decomposition Analysis

Any change in the output of a crop in physical term depends fundamentally on the changes in the area under the crop and its average yield. To determine the source of production growth and to measure the effect of area, productivity and their interaction in increasing crop output, differential equation given by Sharma (1977).

Change in production = yield effect +Area effect + Interaction effect

$$\Delta P = Ao\Delta Y + Yo\Delta A + \Delta A\Delta Y$$

ΔP = Change in production

Ao = Area in base year

An = Area in current year

Yo = Yield in base year

Yn = Yield in current year

ΔA = Change in area (An -Ao)

ΔY = Change in yield (Yn - Yo)

Compound growth rates for the area, production and yield of jowar was analyzed by using the exponential function for major jowar growing districts of Andhra Pradesh and state as a whole and presented in Table.1. The study period was divided into three sub-periods *i.e.,* period-I (1966-1986), period-II (1986 - 2001) and period-III (2001 - 2016), thus the total study period consists of 51 years from 1966 to 2016.

In comparison with period I, II and III, period III registered highest negative growth in area and production among which Khammam (-24.05, -23.19) and Warangal (-22.07, -20.23) observed highest negative growth in area and production, in contrary to Guntur (5.97,19.14) and Nellore (8.57,14.33) which registered positive growth in area and production. Production decline was less than the area decline mainly due to the positive yield growth. Highest increase in yield was observed in Guntur (12.42) followed by Nellore (5.31).

From the Fig: 1, it can be observed that the steep decline in area and production started in period II and it got more pronounced in period III.This decline was due to both supply and demand side factors, In contrast to this, Nellore performed well in period III in terms of area and production in comparison to period I and period II. It can be observed from dendrogram that Kurnool and Anantapur performed in the same manner as compared to other districts. In contrast to this Guntur has performed all the way different from the rest of the districts and state as a whole. Andhra Pradesh state as a whole, area and production growth were -5.96 percent and -3.25 while yield observed positive growth of 2.89 percent. Further growth in area was decomposed in to area, yield and interaction effect from Table 2, it can be seen that except in period I growth in production mainly contributed by yield (-5.35) rather than area and interaction.

Table 2: Decomposition of production growth of jowar into area and yield effects

Years	Area effect (%)	Yield effect (%)	Interaction effect (%)
1966-1986	5.56	96.37	- 1.93
1987-2001	-117.66	140.02	77.64
2001-2016	-239.07	132.27	206.80
1966-2016	-267.32	110.22	257.10

Table 1 : Compound annual growth rates of area, production and yield of jowar in major producing districts of Andhra Pradesh

Period	Period I 1966-86			Period II 1987-2001			Period III 2001-2016			Overall period1966-2016		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Mahbubnagar	-0.71***	0.67	1.39	-3.74*	-2.33	1.46	-12.54*	-10.50*	2.34***	-4.86*	-2.93*	2.03*
Kurnool	-1.52*	2.16*	3.74*	-5.25*	-3.58*	1.77	-3.50*	-2.72***	0.8	-3.74*	-0.26	3.61*
Nalgonda	-3.5	-1.79	1.77***	-11.82*	-10.45*	1.55**	-19.60*	-19.08*	0.64*	-8.87*	-7.42*	1.59*
Adilabad	-0.25	-0.62	-0.37	-3.72*	1.64	5.56*	-14.44*	-14.01*	0.49	-4.71*	-2.90*	1.89*
Warangal	-3.27*	-3.44*	-0.17	-11.35*	-11.02*	0.37	-22.07*	-20.23*	2.36**	-10.18*	-9.49*	0.77*
Khammam	-3.73	-1.63	2.18**	-10.72*	-10.37*	0.39	-24.05*	-23.19*	1.14	-11.67*	-10.74*	1.05*
Guntur	-5.81*	-5.37	0.48	-18.01*	-14.95*	12.01	5.97	19.14*	12.42*	-6.92*	-2.06*	5.23*
Nellore	-3.89	-2.13**	1.83**	-22.19*	-18.83*	4.31*	8.57*	14.33*	5.31**	-9.52*	-5.77*	4.14*
Anantapur	-4.05*	0.09	4.31*	-6.60*	-4.91*	1.81	-2.89	-11.53*	-8.90*	-5.21*	-4.41*	0.84*
Medak	0.19	0.78	0.59	-3.17*	-1.57	1.66	-16.87*	-16.13*	0.89	-4.52*	-2.89*	1.70*
Andhra Pradesh	-2.07*	-0.36	1.74*	-5.94*	-3.66*	2.43***	-12.00*	-6.67*	6.05*	-5.96*	-3.25*	2.89*

Note: *Significant at 0.05% level, **Significant at 0.1% level, ***Significant at 1% level

Table 3 : Instability analysis of area, production and yield of jowar in major producing districts of Andhra Pradesh

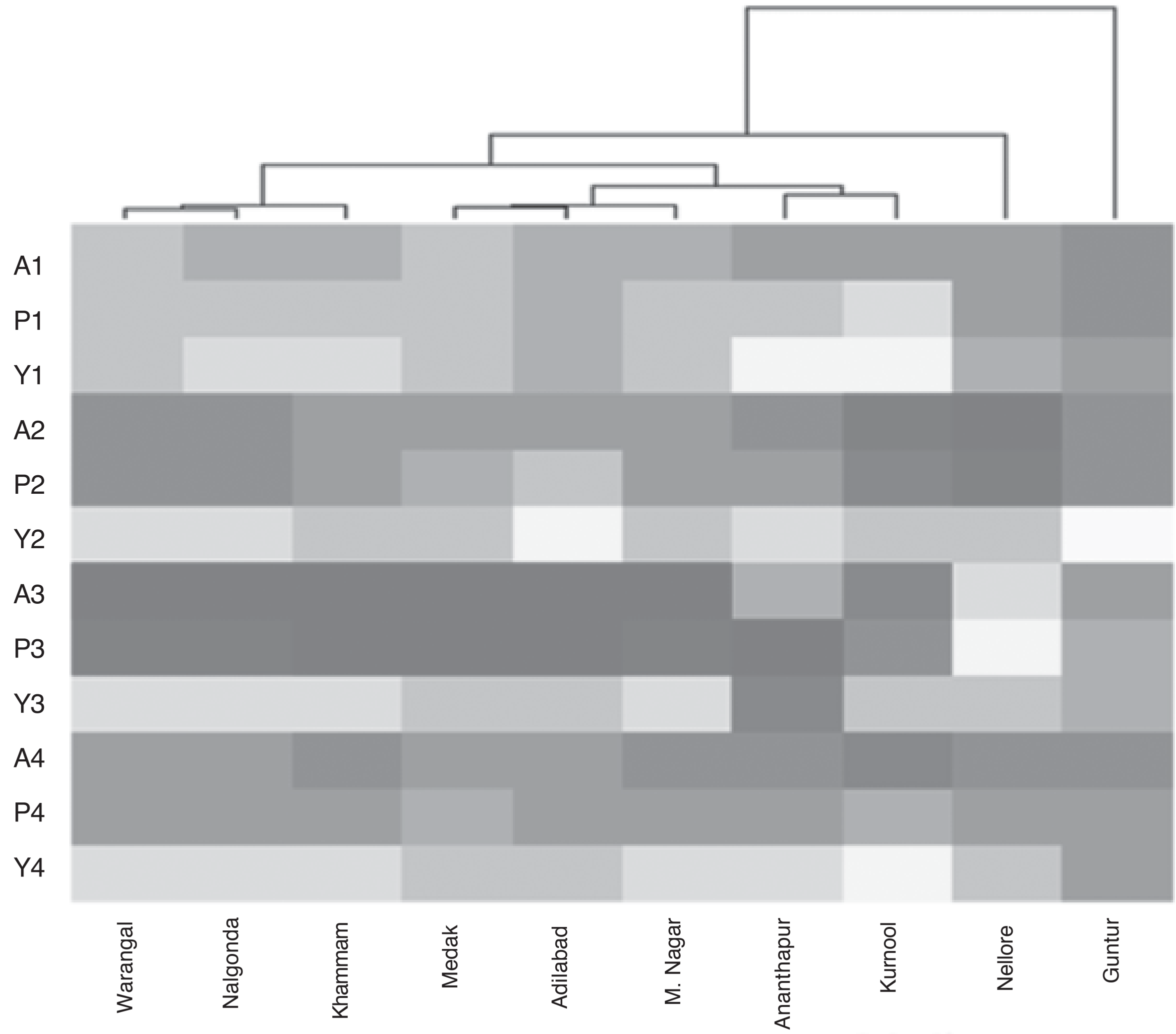
Period	Period I 1966-86			Period II 1987-2001			Period III 2001-2016			Overall period1966-2016		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Mahbubnagar	10.06	26.59	22.89	15.11	24.8	17.56	10.8	26.49	20.2	24.5	31.6	21.4
Kurnool	12.11	28.14	27.93	9.8	16.86	18.06	18.74	23.76	15.84	14.89	27.92	21.99
Nalgonda	8.89	34.77	27.7	15.76	11.51	12.55	26.49	37.13	36.54	27.7	36.23	27.8
Adilabad	7.26	18.64	17.69	7.16	31.57	27.61	17.84	22.47	22.92	25.98	30.6	27.32
Warangal	14.09	27.31	21.34	23.58	41.72	28.41	45.6	44.07	20.57	36.03	38.02	24.14
Khammam	16.97	35.35	21.28	13.18	24.42	16.68	37.73	46.56	24.15	34.35	39.93	23.53
Guntur	7.95	21.39	20.57	16.46	32.12	35.97	73.7	61.2	22.53	56.06	85.59	71.47
Nellore	11.79	30.57	23.87	30.11	28.91	32.6	58.47	71.19	34.03	46.47	59.72	39.92
Anantapur	14.42	29.7	27.52	27.58	29.84	28.25	61.53	62.05	29.3	30.59	37.07	44.34
Medak	8.52	23.95	24.19	5.33	19.89	18.58	30.85	32.51	14.41	28.93	31.25	21.84
Andhra Pradesh	7.48	16.12	13.9	5.91	18.61	14.43	17.21	16.13	15.54	20.13	19.08	24.01

The decline in the area was mainly due to poor profitability *vis a vis* other crops. Jowar lost most of its area to cotton and groundnut (Rao and Parwez, 2005). With the development of poultry industry, increased demand for maize and better availability of hybrids in the maize, there was a shift in the area from jowar to maize (Rao, *et.al.,* 2008).

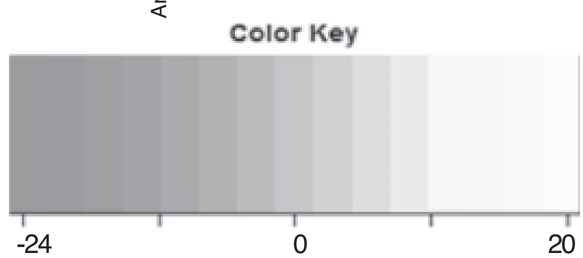
District wise analysis revealed that 1966-2016, Khammam (-11.67, -10.74) and Warangal (-10.18, -9.49) observed to be the highest decline in area and production. In case of yield, Guntur (5.23) registered the highestgrowth, followed by Nellore (4.14) and Kurnool (3.61). The rate of decline in production of jowar was predominantly due to fall in the area sown to this crop. Rapidly changing food habits in favor of fine cereals like rice and wheat and non-inclusion of coarse cereals in the PDS are quoted as major reasons for this drastic trend (Rao, *et al.,* 2008).

It can be seen from the illustration 1 that from 1966-2016 i.e., overall period there was a decrease in area and production, decrease in production was less than the area decreases because of yield effect, it was also evident from decomposition analysis presented in Table 2.

Fig 1: Heat map of Jowar area, production and yield of Andhra Pradesh



A= Area	1=1966-1986
P=Production	2=1987-2001
Y=Yield	3=2001-2016
	4=1966-2016



The result of instability in the area, production and yield of jowar have been presented in Table 3. Variations in the area, production and productivity are a cause for concern. Hence, it is important to know the extent of variability in the area, production and productivity. The variability in the area, production and productivity are analyzed by computing the instability index. Jowar production exhibited a higher degree of uncertainty when compared to area and productivity in all the districts of Andhra Pradesh and state as a whole (1966-2016). The highest variation in production and yield of jowar was found in Guntur (85.59, 71.47) followed by Nellore (59.72, 39.92) respectively. In Andhra Pradesh state as a whole (1966-2016) variability in area, production and yield was 20.13, 19.08 and 24.01 respectively.

Sub-period wise analysis revealed highest area and production variation in period III as compared to compared with period I and period II, period III registered the highest variation in area and production. In period I Khammam (16.97) registered the highest variation in the area followed by Anantapur (14.42), where as in case of production and yield, Nalgonda (34.77, 27.70) and Khammam (35.35, 21.28) registered the highest variation. In period II Nellore (30.11) registered the highest variation in area while Warangal (41.72, 28.41) and Guntur (32.12, 35.97) registered the highest variation in production and yield.In contrast to this Nalgonda (11.51, 12.55) registered the lowest variation in production and yield. Similarly, in period III Nellore and Anantapur registered the highest variation and Adilabad registered the lowest variation.

Conclusion

The above discussion highlighted the fact that the growth in area and production of jowar showed a substantial annual decrement. However, yield of the jowar was recorded a positive annual increment with high instability. Therefore, it is necessary that measures should be taken to reverse the decreasing trend in area under jowar in order to ensure food requirement in the state. Thus, there is a need to take up productivity enhancing measures in this crop like varietal improvement, improved cultural practices, and distribution of planting materials, disease control measures, and selection of appropriate variety according to agro climatic conditions. The extension of cultivable land can be accomplished only by investing more in irrigation – oriented activities. Increasing the area under jowar cultivation can be achieved by policy initiations of government.The government policies should strengthen the extension machinery to improve farmer's practices through extension service and training programmes, so that farmers can adopt available agricultural technology more efficiently.

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PERCEPTION OF THE FARMERS TOWARDS NEEM COATED UREA IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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In fact, the use of chemical fertilizers in India over the last 50 years has grown nearly 170 times (FAO, 2006).The most common nitrogenous fertilizer, Urea, with the highest nitrogen content (46 per cent), is used widely across the countries of the world as the main source of critical nutrient for crop growth. As per research findings, nitrogen from urea is released in the soil and water and is leached by the activity of nitrifying bacteria, *Nitrobacteria* and *Nitrosomonas*. These bacteria turn nitrogen into nitrite and then to nitrate which are highly mobile in nature when present in soil. In the process, approximately fifty per cent of the applied nitrogen in urea is lost through leaching into the soil, causing extensive ground water contamination. Neem coated urea (NCU) is a solution to the problem, preventing the bacterial activity of nitrification. Recent research indicates that 'sustained release' nature of Neem Coated Urea has resulted in reasonable increase in rice yield by 9.6 per cent and wheat yield by 6.9 per cent.

The Government of India decided in January, 2015 to make it mandatory for the indigenous Urea producers to produce a minimum of 75 per cent Neem Coated Urea, out of the total domestic production. This cap was then raised to 100 per cent from May, 2015 onwards, so that the farmers are benefitted and diversion of urea for other industrial use can be stopped altogether.

The National Fertilizer Ltd adopted the technology for coating of Urea with neem oil from Indian Agricultural Research Institute and produced NCU and evaluated the product for rice during 2002 at farmers' fields under North Western India. From the 15 field trial it was focused that after applying the NCU at recommended rate of nitrogen, it produced 1.3–11.1% higher grain yield of rice than ordinary Urea in different districts of north western India (Singh, 2004). According to recent research, the "sustained release" nature of Neem Coated Urea has seen rice yields jump by 9.6 per cent and wheat by 6.9 per cent. (Datta, 2016).

With this back ground a need was felt to assess the perception of the farmers on benefits of the application of Neem Coated Urea in crops under New Urea Policy-2015 initiated by the Government of India with the following objectives.,

1. To study the perception of the farmers towards Neem Coated Urea
2. To assess the relationship between profile characteristics of farmers and their perception towards Neem Coated Urea.
3. To elicit constraints and suggestions for adoption of Neem Coated Urea

Ex-post facto research design was adopted for the study. The study was conducted during 2016-17 in Prakasam district of Andhra Pradesh. Sixty farmers from twelve villages (from each village 5 farmers) were randomly selected to study their perception on Neem Coated Urea. To analyze the perception of the farmers on Neem Coated Urea schedule was constructed with 9 statements on three point continuum i.e., Agree, Undecided and Disagree and scores of 3, 2 and 1 were assigned to the responses respectively. Correlation analysis was carried out to assess the relationship between profile characteristics of farmers and their perception towards Neem Coated Urea. Each farmer was also interviewed by posing open ended questions so as to unearth constraints he/she has experienced and suggestions for NCU adoption. The data were collected by using pre tested schedule employing personal interview method. The responses were scored, quantified,

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categorized and tabulated using mean, standard deviation,correlation, frequencies and percentage

The results pertaining to perception of the farmers on Neem Coated Urea were presented in table 1 & 2. It could be inferred from the table 1 that forty five per cent of the farmers were with medium perception followed by high (36.67%) and low (18.33%) categories. The reason for this result was majority of the farmers had positive perception regarding the uses of NCU with their practical experience in using NCU. Majority of the farmers agreed that NCU is beneficial & cost is reasonable (80.00%), pest and disease incidence was reduced with the use of NCU (71.67%), 'N' fertilizer quantity is reduced with the use of Neem Coated Urea (63.33%) ,cost of cultivation was reduced with the use of NCU (55.00%) and for all crops NCU use is effective (48.33%). Very meager difference with respect to price of NCU (5% more) over Normal Urea (NU) made farmers to perceive NCU was available with reasonable cost. Insecticidal properties of the neem might have facilitated reduced pest incidence. Increased Nitrogen Use Efficiency (NUE) in terms of optimum crop growth with lower NCU use was the reason expressed by the farmers to use reduced doses of Nitrogen fertilizers. Nitrogen (N) fertilizers take the major proportion in total fertilizers consumption in most of the crops which ultimately affects the cost of cultivation. With decreased use of N fertilizers the cost of cultivation also decreased ultimately. Ramappa and Manjunatha (2017) reported that majority of the farmers found decreased pests and diseases and improved soil health with Neem Coated Urea over normal urea. Majority of the farmers disagreed that yield increase with the use of NCU (63.33%), NCU is effective in all situations (58.33%), NCU is available locally (51.67%). This might be true for the reason that the benefits of NCU are better under favorable climate conditions such as an adequate moisture availability and timely application.

Table 1: Overall perception of the farmers on Neem Coated Urea

n= 60

Perception category	Frequency	%
Low (< Mean-SD)	11	18.33
Medium (Mean+/-SD)	27	45.00
High(>Mean+SD)	22	36.67
	60	**100.00**
Mean= 20.53, SD=4.5		

Table 2 : Perception of the farmers on Neem coated urea

n= 60

S.No	Perception	Agree		Undecided		Disagree	
		F	%	F	%	F	%
1.	Neem coated urea is beneficial	48	80.00	8	13.33	4	6.67
2	'N' fertilizer quantity is reduced with the use of neem coated urea	38	63.33	12	20.00	10	16.67
3	Cost of cultivation was reduced with the use of neem coated urea	33	55.00	20	33.33	7	11.67
4	Pest and disease incidence was reduced with the use of neem coated urea	43	71.67	12	20.00	5	8.33
5	Yield increase with the use of neem coated urea	14	23.34	8	13.33	38	63.33
6	In all crops neem coated urea use is effective	29	48.33	3	5.00	28	46.67
7	In all situations using neem coated urea is effective	16	26.67	9	15.00	35	58.33
8	Neem coated urea is available locally	25	41.67	4	6.67	31	51.67
9	Neem coated urea cost is reasonable	48	80.00	9	15.00	3	5.00

Relationship between profile characteristics of farmers and their perception on Neem Coated Urea

A perusal of Table 3 reveals that awareness on NCU, trainings undergone, innovativeness, education and extension contact of the farmers had significant positive relation at 0.01% level with their perception on NCU. Whereas age, farming experience and farm size were found non significant. Awareness is the first and foremost factor contributes to knowledge, adoption and perception of the farmers on any innovative technology, this particular variable had positive relation with perception. Trainings undergone helped the farmers to gain knowledge on reduced use of N fertilizers with the use of Neem Coated Urea use. Innovativeness is another factor which might have facilitated farmers to get more awareness on NCU. The extension contact of the farmers will definitely help the farmers to update themselves with recent agricultural technologies. With more number of trainings, more innovativeness, good education and extension contact farmers had good perception on Neem Coated Urea.

Table 3 : Relationship between profile characteristics of farmers and their perception on Neem Coated Urea

n= 60

S.No	Variable	Correlation coefficient (r)
1.	Age	0.10 NS
2	Education	0.42 **
3	Farming Experience	0.12 NS
4	Awareness on neem coated urea	0.71 **
5	Farm size	0.10 NS
6	Extension contact	0.36 **
7	Innovativeness	0.49 **
8	Trainings undergone	0.52 **

NS –Non significant ** significant at 0.01% level

Constraints and Suggestions expressed by the farmers in adoption of Neem Coated Urea

From table 4 it is evident that almost seventy percent (68.33%) of the farmers felt that lack of awareness on use of neem coated urea was the major constraint followed by local non availability (53.33%). Similar constraints were reported by Ramappa and Manjunatha (2017). Hence, they suggested that there is a need for spreading awareness regarding NCU and its potential benefits, considering that the union government as a policy response, has made the production of NCU mandatory. Farmers suggested that creating awareness among farmers (65.00%), making neem coated urea local available (55.00%), conducting demonstrations to prove N use efficiency with NCU (43.33%) and trainings to farmers on reduced use of NCU use (35.00%) will increase the adoption of Neem Coated Urea

As a majority of farmers perceive NCU as being better than NU, it can be expected that there won't be any problem in continuing with the production of NCU across the country. However, special efforts are required in respect of creating awareness among the farming community regarding NCU and its associated benefits over Normal Urea (NU), as the new policy of the central government has completely stopped the production of NU.

Table 4 : Constraints and suggestions expressed by the farmers in adoption of Neem Coated Urea

n= 60

S.No	Constraint	Freq.	%
1.	Lack of awareness on use of neem coated urea	41	68.33
2.	Locally not available	32	53.33
Suggestion			
1.	Creating awareness among farmers	39	65.00
2.	Local availability	33	55.00
3	Conducting demonstrations to prove N use efficiency with Neem coated urea use	26	43.33
4	Trainings to farmers on reduced use of Neem coated urea use	21	35.00

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Research Note
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A SURVEY ON WORKING ENVIRONMENT AND PROBLEMS OF THE MAIZE VENDORS

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In many cities and towns of developing countries, street food vending is a large source of employment (Choudhury *et al.,* 2011) and contributes significantly to household incomes (Biswas *et al.,* 2010). Roasted maize cob (Bhutta) is classic Indian street food that would be found generally at the beginning of the rainy season or the monsoons. Roasting of maize is done by placing it on a glowing charcoal and then turning it occasionally to allow even distribution of heat. Various indigenous roasting equipments are used by vendors for roasting purposes like tandoor, barbecue, grill, corn roaster etc. A hand fan is used by the vendor to blow the air so as to maintain the glowing of charcoal. The rate of heat transfer from the charcoal to the maize depends on how fast the hand fan blows the air current. For constant supply of air; hand fan and blower are preferred. In the models of stoves used by the local street vendors only two or three corns can be roasted at a time. When the number of customers is more, it becomes difficult for the vendor to cater to all at the same time. There are a number of problems being faced by the road side vendors. Despite problems and risks associated with the business, people continue to use this as a source of earning their living (Pearce and Bankole, 1988).

This study was taken up with an objective to understand the working environment of the maize cob vendors as well as the problems faced by them while roasting the maize cobs.

The study was conducted in Hyderabad city, Telangana State, India. 30 maize roasting vendors operating in the major streets of Hyderabad city were randomly selected for the interview to elicit information on their working environment and the problems faced by them during their work.

Demographic profile of the vendors

The results showed that about 46.67% of the vendors were between 31-50 years of age among which about 37% were women vendors. About 26.67% of the men vendors were below 30 years of age. Out of the total sample, about 66.66% were uneducated among which majority were women vendors i.e. 43.33%. Only about 26.67% of the vendors had primary education among which 20% were men vendors. Maize roasting was the main source of income for 80% of the vendors in which 40% were men and 40% were women vendors. While the rest 20%, adopted roasting of maize cobs as their secondary occupation. The per day earning of the vendors ranged between Rs 100 – Rs 250 for majority i.e, 63.33%. About 20% of the vendors earned between Rs 401 - Rs 550. The remaining 16.67% earned between Rs 251 - Rs 400.

Work profile of the vendors

The results showed that 53.33% of the vendors had an experience between 12 – 21 years among which majority were the women vendors (36.67%). About 30% of the vendors had an experience of below 11 years among which majority were the men (26.67%). It was further observed that maximum of the vendors (70%) worked for 3-6 hours daily. Nearly half of the vendors (53.3%) did not have any helpers for them while among those who had helpers, mostly were the women (46.7%). During season, men vendors received 50 customers on an average while for women vendors, the average number of customers were 34.

Workstation & working equipment related information

It was found that majority (86.7%) of the vendors had readymade workstation; it was purchased as available in the market while only 13.3%

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of the vendors had customized workstation; it was built up according to their requirements as well as the materials available. All of the readymade workstations were movable and all the customized workstation did not have mobility facility. Near about 53% of the readymade workstation had sitting provision among which maximum (20%) carry plastic stool with them while 6.7% carried plastic chair with them. 16.6% of them had the space to sit on and around the footpath/ground and 10% of them made a place for sitting on the cart itself. In the customized workstation, all of them chose to sit on the footpath/ground. For more than 50% of the vendors, the total cost of the workstation varied between Rs 2500-Rs 5500. Only about 10% had spent more than Rs 8500 in purchasing the workstation. Nearly 16% had spent less than Rs 2500 while for 20%, its cost varied between Rs 5500-Rs 8500. Nearly 6.7% of the total vendors used customized iron chulah/stove for roasting of the corns while other 6.7% samples used readymade steel Chulah/stove for roasting. The remaining 86.7% populations used readymade iron Chulah/stove for roasting. With customized workstation, nearly 13.3% of the vendors had difficulty in carrying out the task while an equal percentage of population (13.3%) with readymade workstation found it easy to operate. Maximum of the population (73.3%) with readymade workstation found difficulty in carrying out the work of roasting.

Problems faced during working

All of the women vendors felt pain in all the body parts including shoulder, neck, arm, wrist, lower back, fingers, legs and eyes. 100% of the men vendors felt pain only in the arms and wrists. During the process of roasting, the common problem faced by all the vendors was of burns. The figure 1 clearly shows that 60% of the men and 80% of the women vendors had burn marks on their hands which were caused due to the sparks of coal. All the men and women vendors (100%) had burn marks on their clothes; small holes were created due to the sparks of coal. Nearly 13% women and 20% men vendors had suffered from injury (burn marks) caused by the falling of burning coal on their legs.

The turning of corn cobs during roasting process causes the fingers of the vendors to touch the hot coal which causes burning sensation on their fingers. This is the problem faced by all the vendors including men as well as women vendors. Nearly 33% of the men and women vendors suffered from the problem of reddening of the skin since, they work in front of fire for number of hours. Nearly 73% of the women vendors faced problem in doing the work by standing since their abdominal area was exposed to the direct heat which caused them burning sensation in internal organs. Similarly 40% men vendors suffered from the problem of heat on abdominal area.

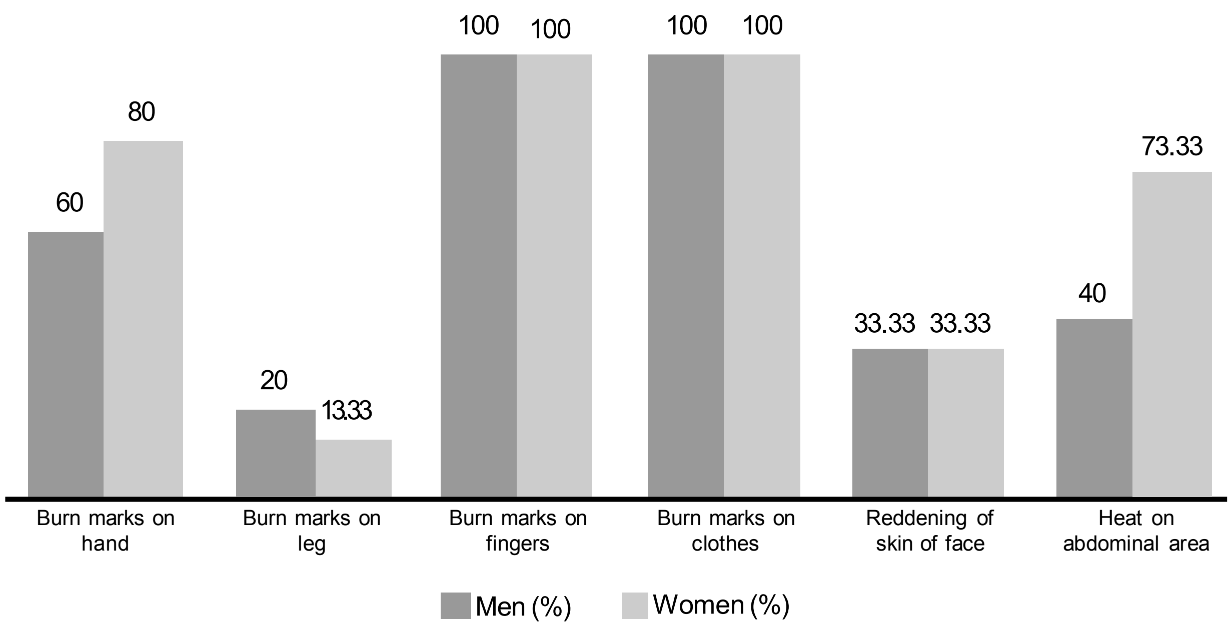

Figure 1 : Percentage of samples facing different problems

It can be concluded that mostly the women in this business were middle aged while majority of the men were below 30 years. Majority of the women were uneducated while more than half of the men population was educated but most of them have left their schooling in between to support their family by adopting corn cobs roasting business. The majority of the vendors had adopted maize roasting as a major source of their income. The season when output of corns is more, maximum number of customers any vendor received was about 100 and minimum was near about 15 to 20. A positive correlation was observed between no. of years of experience and availability of assistance. Women vendors were found to be more prone to the pains in different body parts caused due to the process of roasting corns possibly because of the double work load of household and also income generation. Increasing age of majority of respondents could also be a probable reason. A positive correlation was shown between age and frequency of pain in neck, wrist, lower back, fingers and eyes. The correlation between age of the vendors and intensity of pain felt by them showed that both were positively correlated. Majority percentage of the vendors had the problem of burning of fingers, burning of clothing and burn marks on hands due to sparks. Mostly the women vendors suffered from the direct heat on the abdominal area. Falling of burning coal and reddening of the skin of the face due to long hours of working in the fire were also the problems stated by the vendors. Nearly all the vendors had difficulty in controlling the fire and roast the corns when air blows vigorously.

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