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INDIAN SEED SECTOR - CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Seed is a bridge of hope between present and future and is inevitable for life's continuity. India has a vibrant seed market. Over the years, the seed industry has evolved side by side with Indian agriculture. From the practice of saving seeds from the previous crop, Indian farmers have come a long way. Today, the Indian seed industry is the fifth largest seed market in the world, accounting for 4.4% of global seed market. In terms of global trade, India is almost self-sufficient in flower, fruits and vegetables and field crops seeds. Overall, paddy, maize and vegetables are expected to drive the growth of Indian hybrid seed industry in the next five years. The government's policy support has also gone a long way in supporting the seed industry's evolution and development. From the Seed's Act of 1966 to the Seed's Bill 2004, India's seed policy has been suggestive of India's evolving needs and market dynamics. Conducive policy reforms and government support has spurred the transformation of this industry in recent times. Private seed sector has played a major role in changing Indian seed sector. Investment and technical expertise garnered from different parts of the world has made this fete possible. This review emphasizes on evolving of Indian seed sector, its growth, future challenges and expansion to export market.

Key words: Seed sector, seed replacement rates, seed policies, public and private seed industry

Seeds in fact were responsible for many revolutions and transformations that our country had witnessed. The famed' Green Revolution' that took India's agriculture to new heights was also based upon the seeds of High yielding varieties of wheat that produced good yields. Similarly, 'Bt cotton' transformed India's cotton economics. Invariably good seeds produced good results. But arriving upon a good seed is a herculean task. It involves years of research and standardization procedures before it reaches the farmers. Today, most of the farming in India depends upon these seeds that are released either by research stations or private companies. These seeds have become the staple of Indian agriculture. Seeds form a crucial and unavoidable component of agriculture. They convert the resources and labour into fruitful harvest. In fact the response of all other inputs depends on the seed itself. Studies have pointed that quality seeds can alone contribute to about 15-20% to the total production depending upon the crop and it can be further raised up to 45% with efficient management of other inputs. It is the fact that the increase in availability of quality seed has a huge bearing on food grain production (Chauhan *et al.* 2013).

The growth of seed industry has been commensurate with that of Indian agriculture. At each step, the Indian agriculture was amply supported by the seed sector. Sixties were particularly a crucial time in Indian seed sector and several significant and impactful events occurred during this time. In 1963, National Seed Corporation (NSC) was established. The objective was to undertake production of foundation and certified seeds. Now it has grown into a Schedule 'B'-Miniratna Category-I company wholly owned by Government of India under the administrative control of Ministry of Agriculture and Farmers Welfare. At present, NSC is undertaking production of certified seeds of nearly 600 varieties of 60 crops through its registered seed growers. There are about 8000 registered seed growers all over the country who are undertaking the seed production programmes in different agro-climatic conditions (National Seed Corporation Limited, www.indiaseeds.com, 15.01.2015). The Government of India enacted the Seeds Act in 1966 to regulate the growing seed industry. The Seeds Act stipulated that seeds should conform to a minimum stipulated level of physical and genetic purity and assured percentage germination either by compulsory labelling or voluntary certification. Further, the Act provided a system for seed quality control through independent State Seed Certification Agencies which were placed under the control of State Departments of Agriculture (Agriculture today, 2016).

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The eighties were also impressive for seed sector as it witnessed two more important policy developments for the seed industry, viz. granting of permission to MRTP (Monopolies and Restrictive Trade Practices)/FERA(Foreign Exchange Regulation Act) companies for investment in the seed sector in 1987 and the introduction of 'New Policy' on seed development in 1988. Besides this, the time saw launching of the World Bank aided National Seeds Programme (1975-85) in three phases leading to the creation of State Seeds Corporations, State Seed Certification Agencies, State Seed Testing Laboratories, Breeder Seed Programmes etc. Seed Control Order (1983), Creation of the Technology Mission on Oilseeds & Pulses (TMOP) in 1986 now called The Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM), Production and Distribution Subsidy, Distribution of Seed Mini-kits and Seed Transport Subsidy Scheme were also enacted during the same period. Seed sector garnered further support in the beginning of nineties. Under the 1991 Industrial Policy, seed production was identified as a 'high priority industry'. In line with India's larger liberalization and privatization policies during the same period, the new policy on Seed Development opened the doors for import of vegetable and flower seeds in general and seeds of other commodities in a restricted manner and also encouraged multinational seed companies to enter the seed business. As a result more than 24 companies initiated research and development activities. Further to strengthen the seed sector and to address certain unattended areas in Seeds control order, National Seed Policy, 2002 was initiated. The aim was to provide intellectual property protection to new varieties; usher this sector into planned development; protect the interest of farmers and encourage conservation of agro-biodiversity. This national seed policy, 2002 had 10 thrust areas - Varietal Development and Plant Varieties Protection, Seed Production, Quality Assurance, Seed Distribution and Marketing, Infrastructure facilities, Transgenic Plant Varieties, Import of seeds and planting materials, Export of seeds, Promotion of Domestic Seed and Strengthening of monitoring system. Under this policy the Protection of Plant Varieties & Farmers' Rights Authority (PPV&FRA) was established to undertake registration of extant and new plant varieties. A National Gene Fund was also created for implementation of the benefit sharing arrangement, and payment of compensation to village communities for their contribution to the development and conservation of plant genetic resources and also to promote conservation and sustainable use of genetic resources. The National Seeds Board (NSB) was established in place of existing Central Seed Committee and Central Seed Certification Board which was entrusted with the responsibility of executing and implementing the provisions of the Seeds Act and advising the Government on all matters relating to seed planning and development. The Seeds Bill, 2004 seeks to regulate the production, distribution and sale of seeds. It requires every seller of seeds (including farmers) to meet certain minimum standards. The Standing Committee has recommended seed sales and exchange by farmers to exempt from this requirement. The Bill has been pending since December 2004 (Agriculture today, 2016).

Indian seed sector- Public and Private

The growth of seed industry can be considered parallel to the growth of India's agriculture production. Today, the Indian seed industry is the fifth largest seed market in the world, accounting for 4.4% of global seed market after the U.S. (27%), China (20%), France (8%) and Brazil (6%). (Fig 1).

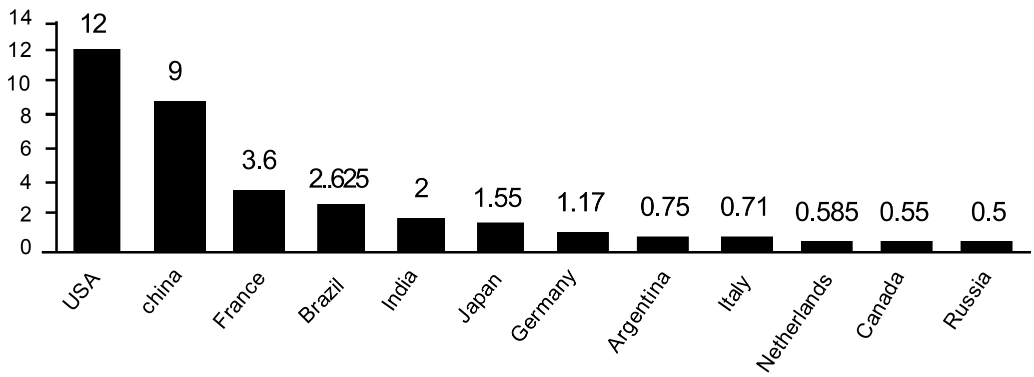

Fig.1: Market size-USD Bn

In terms of global trade, India is almost self-sufficient in flower, fruits and vegetables and field crops seeds. According to Ken Research's report, "Indian Seed Industry Outlook to FY'2018 - Rapid Hybridization in Vegetables, Corn and Rice to Impel Growth", the hybrid seed market has grown at a stupendous CAGR of 36.1 per cent over the period FY'2007-FY'2013. The contribution of varietal seeds to the overall commercial seed market in India has witnessed a steep decline from 72 per cent in FY'2007 to 36.8 per cent in FY'2013. The Indian seed market is majorly contributed by non-vegetable seeds such as corn, cotton, paddy, wheat, sorghum, sunflower and millets. In FY'2013, the non-vegetable seeds accounted for 82.2 per cent of the overall seed market in India. Non-vegetable seed market in India is largely concentrated in cotton, contributing the largest share of 40.8 per cent. Overall, paddy, maize and vegetables are expected to drive the growth of Indian hybrid seed industry in the next five years. It is expected that better rice hybrids will be developed to give a yield advantage of at least 3-4 tonnes per hectare over the research varieties (Fig. 2 &3).

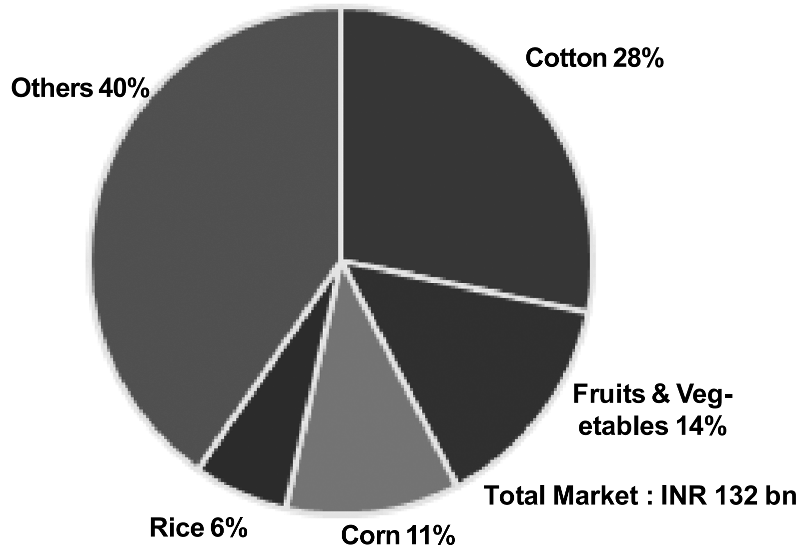

Fig.2 : Indian seed market size by value

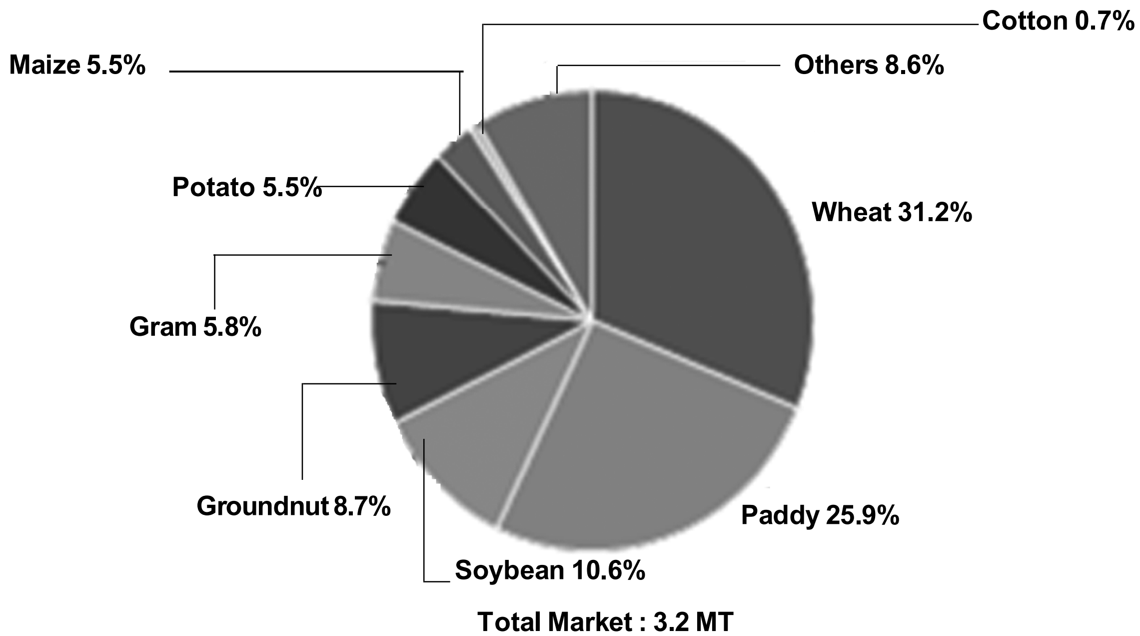

Fig. 3 : Indian seed market by volume

With the arrival of newer forms of seed varieties, the traditional open pollinated varieties have taken a back seat. In 2010, they valued at 0.19 billion USD which was around 12 per cent of total market value. The open pollinated seeds which are saved over years for their desirable trait has a varying Seed Replacement Rate (SRR) of 20-80 per cent (Agriculture today, 2015). (Fig.4)

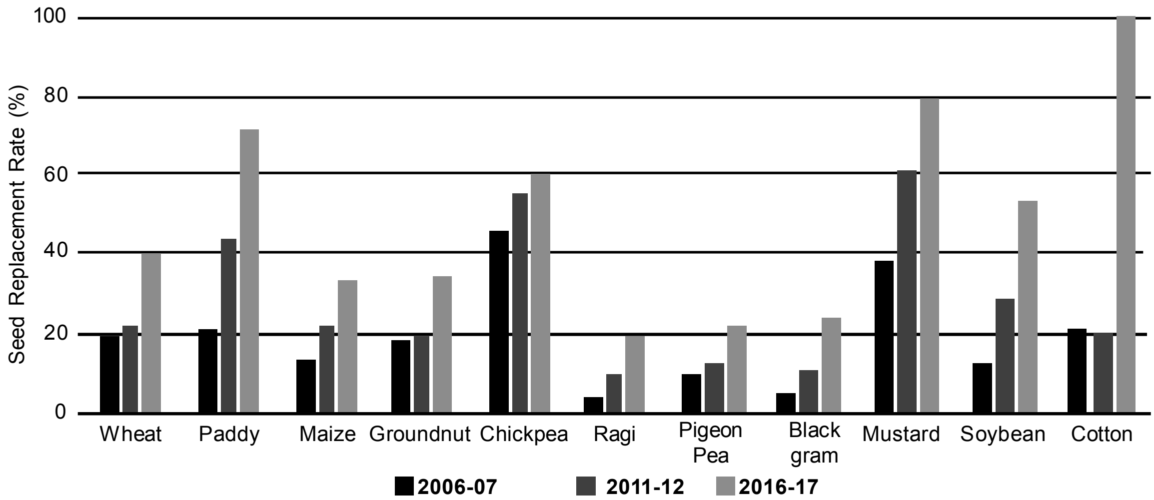

Fig. 4 : Seed Replacement Rate of major crops in India

Seed Sector : Seed Replacement Rate of Major Crops (%), India, 2006-2017

According to the report, the Indian seeds market reached a value of US$ 3.6 Billion in 2017, exhibiting a CAGR of around 17% during 2010-2017 and is further expected to grow at a CAGR of 14.3% during 2018-2023, reaching a value of more than US$ 8 Billion by 2023.The Indian seed market has witnessed a major restructuring as a result of the implementation of some progressive policies by the government. Seed Development, 1988 and National Seed Policy, 2002 have helped in strengthening the Indian seed industry in the areas of R&D, product development, supply chain management and quality assurance. Owing to this, India has emerged as the fifth largest seed market across the globe. Moreover, the active participation of both, public and private sectors has also played a vital role in laying a strong foundation of the industry. This includes launching of initiatives to promote the use of hybrid seeds among the farmers who had earlier used outmoded open pollinated varieties. Some other growth-inducing forces, such as growth in income levels, commercialization of agriculture, patent protection systems and intellectual rights over plant varieties, have given a great push to the market (Agriculture today, 2015) (Fig 5).

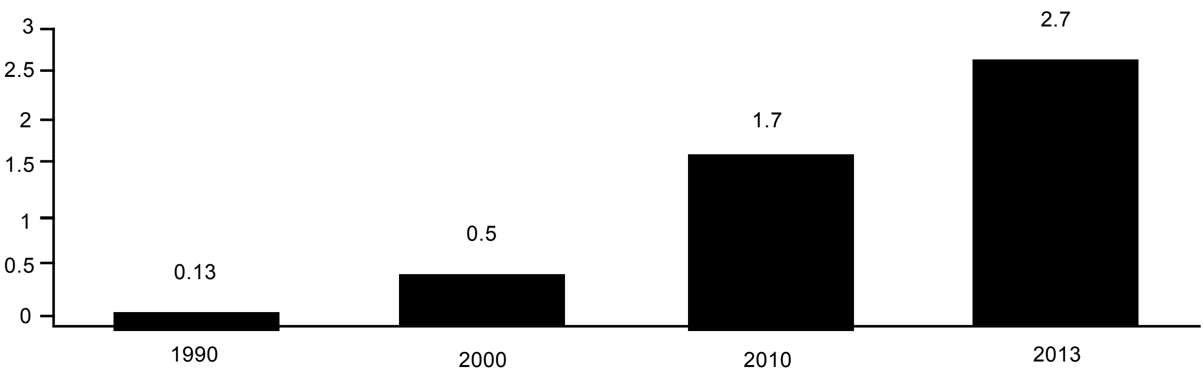

Fig. 5 : Indian Seed Industry growth over years (Value in USD Bn)

At present only government agencies and few small regional players are involved in the multiplication and distribution of traditional and improved varieties of crops. Hybrid seeds, on the other hand, now occupy the highest share in terms of total market value. In fact, this is a promising sector for the private players as this section of seed needs cent per cent SRR. Syngenta, Dupont, Mahyco, J K seeds, Bioseed, Rasi and Bayer are some of the players in this business. The most controversial category of seeds is the one which are genetically modified and more commonly referred to as GM seeds. This category of seeds were seen capturing a good share of markets with heavy investments in R&D. Unfortunately, the unsteady policy measures and wavering government stand has dampened the spirits of this sector. Monsanto, Dupont, Syngenta, Rasi and Pioneer are some of the companies working on this line of seeds. Despite the strong statistics in support of the commercial seed sector, Indian seed market is strongly dominated by the farm saved seeds. Tradition of saving seeds, economic feasibility and ease of using the saved seeds have till now made them the most favoured category of seed varieties among the Indian farmers. Around 75 per cent of seed used in the country falls in this category. Public sector has a strong representation in the country's seed market. This includes 99 ICAR research institutes, 65 Agricultural Universities (SAUs & DUs), 15 State Seed Corporation (SSC), National Seed Corporation (NSC) and State Farms Corporation of India (SFCI). Indian seed programme includes the participation of Central and State governments, Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAU) system, and institutions in public, private and cooperative seed sectors in India consists of two national level corporations i.e. National Seeds Corporation (NSC) and State Farms Corporation of India (SFCI), 15 State Seed Corporations (SSCs) and about 100 major seed companies. For quality control and certification, there are 22 State Seed Certification Agencies (SSCAs) and 104 state Seed Testing Laboratories (SSTLs) (Chauhan et al. 2014b, Datta et al. 2013, National Seed Corporation Limited, www.indiaseeds.com, 15.06.2015). Since late nineties, the private sector has started to play a significant role in the production and distribution of seeds. However, the organized seed sector particularly for food crops (cereals) continues to be dominated by the public sector. The private sector which in India mostly cashes in on high value, low volume crop seeds such as vegetables (Hanchinal 2012). Their research focus is on Pest & disease resistance and most recently into developing varieties that can resist climatic extremities. The private sector is represented by 500 small & medium players and 50 large national & Multinational players (Agrawal 2012a). Among the strong contenders for growth, hybrid seed sector is stealing the show. The Indian hybrid seed market, with over 300 companies, has been growing at 15-20 per cent annually over the past several years and is projected to reach around Rs 18,000 crore by 2018 (Agriculture today, 2015).

Indian Seed Industry compared to global scenario

The seed industry market size is more than doubled when compared between 2009-10 and 2014-15. Within a period of five years, the market has grown from Rs 6000 Crores to Rs 13500 Crores. Coupled with increasing domestic demand and demand for quality seeds in various foreign countries, mainly the South East Asian countries, seed industry in India is witnessing new paradigms of growth and development. When compared to the global seed production India´s share is very less. India is way behind countries like USA and China in terms of total seed market size. In 2014, the total seed market size of USA was almost USD 12 billion while that of China was USD 10 billion. When compared to just these two countries, India's total seeds market is currently very low at approximately USD 2.2 billion. According to a market research report recently published by Sandler research.org, the Global Seeds Market size is expected to grow at a cumulative annual growth rate of about 11% between 2015 and 2019. (Agriculture Today, 2015). The growth during this period is expected to be driven to a major extent by the increased adoption of genetically modified seeds. Vegetable seed constitutes a major segment of the total seed market. Currently, the vegetable seed industry is estimated to be around USD 350 million in 2014. It is expected to grow at a cumulated average growth rate of 14.6%.There is a steady demand for vegetable seeds in various foreign countries. India is the ninth major exporter of fruit and vegetable seeds in the world there by earning good foreign exchange reserves. Vegetable seeds consist of seeds for vegetables such as cauliflower, tomato, brinjal, spinach, lettuce, watermelon, onion, pepper, watermelon, carrot and others. As a whole, increased demand for food production all over the world and a rise in various agricultural challenges has to a large extent driven the way for the adoption of high-quality, high-performing genetically engineered and hybrid seeds. To meet this demand, various seed companies globally have increased their investment in R&D to improve the quality of seeds. The export of seeds received a major boost when 38 varieties from India were registered with the Organization for Economic Cooperation and Development (OECD). This is a group of 34 countries which guarantees the quality of seeds that can be imported by countries participating in the OECD Seed Schemes. About 57 nations are registered in such seed schemes (Agriculture Today, 2015).

Future Outlook of Indian Seed Industry

The seed industry in India has to align with the changing food consumption scenario of the country. There has been a decline in the proportion of expenditure on food items in last three decades. The change has occurred in both urban and rural areas. Between 1990 and 2010, consumption of cereals and pulses has decreased considerably while consumption of fruits and vegetables has almost doubled. The future seed market of the country is expected to witness more adoption of hybrid seeds. The country is going to witness an increase in the cultivation of vegetables and fruits, driven by the growth and development of the food processing sector along with changing consumption habits of the people. The export sector is also set to witness growth. One of the most important developments in future will be the increased demand for quality vegetable and fruit products, because of the increased consumer awareness and increase in disposable income of the population. As a result of this trend, protected cultivation will increase in India. The current seed industry might also need to develop new products in order to attune with the greater mechanization of agriculture sector in India in the near future, vastly due to labor challenges. One more expected change that the seed industry is going to witness is in the form of an increased demand for fruits and vegetable varieties with higher nutritional values. Life style related health problems are increasing in the country with diseases like obesity, diabetes, malnutrition etc. on the rise and hence people are becoming more health conscious which will propel the use of fruits and vegetables with more nutritional values (Agriculture Today, 2015).

Challenges for seed industry

On global front, population will breach 9 billion mark by 2050 with India leading the march, i.e. each farmer must feed more people with declining land and water resources. On the verge of climate change, seed research is the key to unlock the potential of technologies. In the Indian context, from a long period of time, seed requirement of farmers is mainly met by farm saved seed, i.e. still 65 % of the farmers are using their own saved seed or seed distributed among them (Vision 2050, Directorate of seed Research). Making the quality seed available at right time is greater challenge rather than production per se. Seed, being the principal input in determining productivity, seed replacement should be given utmost priority. Amelioration of skewed SRR, i.e. the percentage of area sown out of total cropped area by using certified/quality seeds other than farm saved seed is the major challenge (Table 1).

Table 1. Seed Replacement Rate in different crops and its variation across states

Crop	National Average SRR (%)	Highest SRR (%)		Lowest SRR (%)	
Paddy	37.5	82.0	Andhra Pradesh	9.0	Uttarakhand
Wheat	32.6	42.0	Maharashtra	11.0	Jammu & Kashmir
Maize	54.1	100.0	Karnataka	5.0	Odisha
Jowar	25.9	65.0	Andhra Pradesh	11.0	Tamil Nadu
Bajra	61.4	100.0	Gujarat	29.0	Karnataka

Crop	National Average SRR (%)	Highest SRR (%)		Lowest SRR (%)	
Bengal gram	18.4	78.0	Andhra Pradesh	4.0	Rajasthan
Blackgram	29.2	77.0	Haryana	3.0	Chattisgarh
Greengram	26.7	94.0	Uttar Pradesh	1.0	Odisha
Redgram	17.5	55.0	Andhra Pradesh	2.0	Odisha
Groundnut	24.5	50.0	Andhra Pradesh	0.5	Madhya Pradesh
Mustard	63.6	78.0	Rajasthan	13.0	Odisha
Soybean	35.9	100.0	Andhra Pradesh	11.0	Rajasthan
Sunflower	61.2	100.0	Andhra Pradesh	8.0	Madhya Pradesh
Cotton	10.4	100.0	Andhra Pradesh	2.0	Odisha

Source: **Directorate of Economics & Statistics, Ministry of Agriculture, GOI {2012} (http://dacnet.nic.in/eands)**

Increasing Seed Replacement Rates in Critical Crops

The growth of the seed industry in any country is dependent on how often farmers are replacing their seeds. The seed replacement rates for almost all the crops in India have considerably improved in the recent times. Over a ten-year period, from 2002 to 2012, the seed replacement rates of key cereal crops have more than doubled, with that of rice experiencing a 111% jump, wheat increasing by 154%, and maize 238%. Increasing seed replacement rates are a result of increased farmer extension and marketing activities of seed companies, as well as the general perception among farmers about yield improvements that can be achieved through replacement of seeds every year.

Even though there is slight improvement recently, still a long way ahead in making the quality seed available at farmers' doorsteps and for achieving 100% SRR, which will herald the growth driven by quality seed in agriculture sector. Another major problem of seed chain is Varietal Replacement Rate (VRR). Even though with more than 4500 varieties, notified and available, indents for basic seed and its further multiplication is restricted to a few varieties. Many improved varieties, which are location specific, resistant to biotic and abiotic stresses never saw the light of the day, may be due to below par extension activities. Hence special focus need to be given on improvement of VRR, which certainly paves the way for improved productivity levels manifested in the form of increased production. Regarding seed

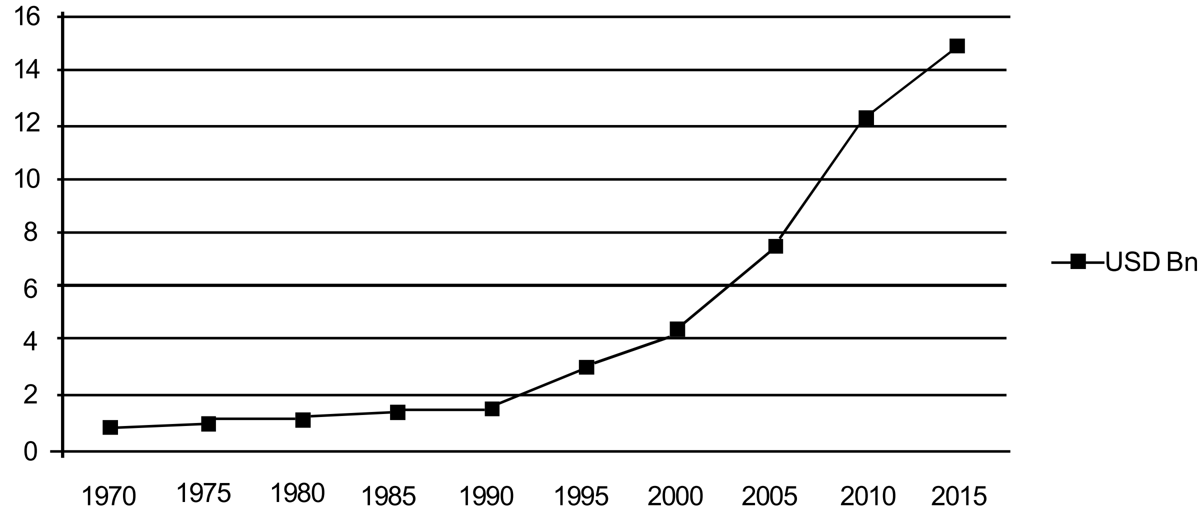

Fig.6 : Global Seed trade

technological research, emphasis has to be given on basic research relevant to floral biology, pollination, seed development and maturation studies in a bid to attain better seed recovery. Refinement of seed production technology in varied crops must be given the highest priority, for enhanced profitability in seed production. Globally, the contemplated research work relevant to fields of seed testing, quality assurance and seed quality enhancement is at par excellence (Table 2).

be proactive to explore export potential and create enabling environment. This can be achieved through a well planned strategy and targeted implementation plan. Future growth drivers of seed industry could be hybrids in crops viz. paddy, maize, mustard, pigeonpea followed by vegetables and flowers. India is a major player in the global paddy market with about 43.0 million ha cropped area. Although having largest acreage under paddy cultivation, productivity is stagnant at about 3.5 t/ha. Hybrid rice could be a game changer for India, as only 4.1 % of area is under hybrid rice. Total paddy seed turnover is Rs. 21.8 billion in 2011. It could be increased to Rs. 42 billion over the next four years, if 50 % of the cultivated area is covered by improved varieties and 10 % by hybrids (ISTA News, 2012). Over the past few years, world demand for maize is increasing due to its alternative usages like biodiesel production. Globally, India ranks 4th in production as well as acreage with average productivity of 2.5 t/ha. In future, global warming is likely to have detrimental effect on wheat and rice cultivation, under such situation, maize, a C4 Plant may play decisive role in mitigating harmful impact of climate change.

Table 2. Quality seed requirement of major crops in the country (Assuming 100% SRR)

Crops	Gross cultivated area (million ha)	Seed Rate (kg/ha)	Certified seed Requirement (000 tonnes)	SMR	Foundation seed requirement (000 tonnes)	Breeder seed requirement(tonnes)
Rice	45.6	50	2280.0	100	22.8	228.0
Wheat	27.2	125	3400.0	20	170.0	8500.0
Sorghum	7.7	15	115.5	160	0.7	4.5
Pearl millet	8.7	5	43.5	200	0.2	1.1
Maize	8.0	20	160.0	80	2.0	25.0
Pigeon pea	3.4	15	51.0	100	0.5	5.1
Chickpea	8.2	80	656.0	10	65.6	6560.0
Groundnut*	6.2	100	620.0	8	9.7	1210.9
R&M	6.3	5	31.5	200	0.2	0.8
Soybean	8.9	75	667.5	16	41.7	2607.4
Sunflower	1.9	10	19.0	50	0.4	7.6
Cotton	9.5	12	114.0	50	2.3	45.6
Jute	0.8	5	4.0	100	0.04	0.4
Total	**142.4**		**8162.0**		**316.1**	**19196.4**

Groundnut foundation seed requirement is calculated on basis of two stage c/s production

In order to match global requirement and to strengthen India's position in international market, there is need for cutting edge infrastructure and world class laboratories accredited to international seed agencies/ institutes. Collaborative research projects in partnership with private seed sector to deliver desired outputs that benefit farming community of the country should be formulated (Vision 2050, 2015).

New Opportunities for seed sector

The nature gifted biodiversity and the diversity in agro-climatic conditions offer exciting opportunities for India to be globally competitive in producing and promoting a number of seed crops for export. We must

Therefore, focus on quality seeds of hybrid maize will largely contribute to growth of Indian seed market in near future. Technological breakthroughs in relevant fields of seed science and technology are quite commendable both at national as well as international domain. Seed testing and quality assurance is one area where lots of policy, infrastructure and human resource support is needed. Establishing world class facilities for seed testing, certification and to match requisites of international conventions viz., UPOV, ISTA etc., so that seed from India can carve its niche in international trade. Even though, India is fifth in position in terms of value share, there is ample scope to amend the figure mentioned and for excelling in international seed trade. India with diverse agro-climatic zones, unlimited options for crops and probably with largest research man power has an enormous opportunity to stamp authority on world seed front. Expanding the know-how of conventional seed science and technology viz., floral biology, pollination, seed development, maturation and seed production technology per se can create formidable opportunities in maximizing the productivity levels thereby food and socio-economic security in the country. Regarding seed quality enhancement, whole spectrums of opportunities are awaiting. Second and third generation seed quality enhancement strategies will play a vital role in giving an altogether new dimension to seed. Seed designing will emerge as a futuristic technology, where seeds are fabricated with all necessary additives that give adequate planting value across diverse agro-climatic zones by insulating them against biotic and abiotic stresses. A new era of seed designing is going to be unraveled in near future, where seeds are bought or sold on number basis making it as the most precious input of cropping system (Vision 2050, 2015).

Opportunities under Seed Quality Augmentation:

Deployment of intelimer additives for coating/ pelleting of seed, Utilization of advanced polymer systems (thermo/hydro) for seed designing , Smart delivery systems (nanotechnology) for controlled release of analytes , State of art disinfection techniques (thermo/ plasma treatments) for seed protection, Deployment of OMICS technologies in seed quality improvement, Development of Image Analysis Systems for seed & seedlings quality assurance are a few techniques worth mentioning.

Prospects of seed export:

India's share in global seed exports is about 0.6 % (ISF, 2012). To give a boost to seed export, India decided to participate in OECD Seed Schemes in five categories viz., Grasses and legumes; Crucifers and other oil or fibre species; Cereals; Maize, sorghum and Vegetables. OECD Seed Schemes is one of the international frameworks available for certification of agricultural seeds moving in international trade. Its objective is to encourage use of seeds of consistently high quality in participating countries. Complying to internationally acceptable procedures of seed quality assurance shall certainly boost our seed exports and enable India a force to reckon with in global seed realm (Vision 2050, 2015).

Opportunities for production of high quality seed

Seed Production Research:

Future of agricultural production will largely depend upon development of improved varieties/ hybrids in various crops, supported by efficient, cost effective seed production technologies. Diversification of areas for seed production and development of appropriate seed production technology needs to be focused for expansion of seed production system in the country. Identification of alternative/specific areas for quality seed production and mapping of disease free seed production zones may go a long way in popularizing seed production technologies in non-traditional areas.

Climate Resilient Seed Production:

The reproduction success in plants is determined largely by the environmental conditions prevailing during the growing season. Among the various environmental factors, moisture and temperature have direct influence on reproduction. Early reproductive processes like pollen viability, stigma receptivity, anthesis, pollination, fertilization, and early embryo development are all highly prone to moisture and/ or temperature stresses. Failure of any of these processes increases early embryo abortion, leading to poor seed set, thus limiting the seed yield. The physiological mechanisms of reproductive failure under stress are not well understood. Hence, considerable efforts should be made to study the effect of climate change on seed production of various crops to develop suitable crop management technologies and mitigate the adverse effects on the reproductive phase (Vision 2050, 2015).

Development of crop and location specific organic seed production technologies and harmonization of organic seed standards

Organic agriculture for sure shall carve its justified niche in future; hence gearing up to the needs of development of crop and location specific organic seed production technologies deserve high priority. Since seed is starting point of production systems, organic seed (production technology, field and seed standards) is inevitable for location specific, producer community based organic agriculture.

Application of GIS/GPS/ Remote Sensing for higher seed productivity:

GPS/GIS applications includes guidance of equipment viz., micro irrigation facilities, fertilizer/ pesticides applicators and tillage implements; mapping of pests and diseases to reduce excess overlaps and skips and enable towards precision in seed production. Quality seed production basically is the enterprise to make available the seeds of highest genetic purity and also possess quality attributes such as high germinability, vigour and freedom from insect pests and diseases. There are different strategies well in place to ensure the highest genetic integrity.

Proprietary Seed Production technology (SPT):

Technology involves using a genetically modified (GM) line to propagate a male sterile line which is then used as one of the parents to produce hybrid seed. The genetic modification is not inherited by the hybrid. The principle of SPT could be applied to other crops, particularly cereals (wheat and rice), some of the pulses and oilseeds where there is a need for better hybrid systems and where alternative male sterility systems are yet to be developed.

Setting up of effective standard operating framework to tackle novel technologies viz., Genetic use restriction technology (GURT):

GURT is the name given to proposed methods for restricting the use of genetically modified plants by causing second generation seeds to be sterile. There are conceptually two types of GURT: Variety-level Genetic Use Restriction Technologies (V-GURTs): This type of GURT produces sterile seeds, so the seed from this crop could not be used for further propagation, but only for sale as food or fodder. If technology ever gets approval this would have an immediate impact on the large number of indigenous farmers who use their farm saved seeds, and instead they would be forced to buy seeds from seed production companies. Consequentially, resistance to the introduction of GURT technology into developing countries is strong. • T-GURT: A second type of GURT modifies a crop in such a way that the genetic enhancement engineered into the crop does not function until the crop plant is treated with a chemical that is sold by the developer. With this technology, farmers can save seeds for use each year. However, they do not get to use the enhanced trait in the crop unless they purchase the activator compound. The technology is restricted at the trait level, hence the term T-GURT.

Seed Quality Assurance/Varietal Maintenance and Testing:

Innovation has different meaning to scientific community, industry and farmers. As far as the farmer is concerned, all the scientific innovations would be of little value unless he gets refined end product (seed), which is genetically pure (true to type) and posses other desired qualities namely, high germination and vigour, sound health etc. Different seed testing protocols currently used in India need to be upgraded on the lines of international standards of seed testing such as ISTA, AOSA and OECD for better seed quality assurance and easy access to international seed trade. Use of biochemical and molecular markers including electrophoresis of proteins, isoenzymes and DNA fingerprinting involving first and second generation markers for establishing the distinctiveness of varieties may supplement Grow Out Test in genetic purity testing. Particular attention needs to be paid on distinguishing closely related and essentially derived varieties (EDVs). Further, focus should be on development of user friendly molecular detection kits for fast and accurate identification of varieties, hybrids, pathogens and GMOs. With increasing biotechnological intervention in different crops and development of GM crops, research on certification standards, isolation distance from non GM crops and cost effective kits for detection of transgenes by using micro array chips and proteomic approaches needs to be carried out.

Seed Biotechnology:

Genomics should be undertaken to discover gene/s governing dormancy, germination and longevity and stress tolerant genes to produce superior quality seeds. Transcriptomics of seed development to unzip molecular regulation of improved seed characters is an area, where immense potential lies for quality improvement. Development of national data base for DNA profiles of crop varieties. Development of DNA bar coding system for tracking the breeder seed production and supply system. Validation/up-gradation of field and seed standards/protocols: isolation distance, sample size, physical purity and ODV. Standardization of minimum weed seed standards and development of interactive software for weed seed identification. Developing mechanisms for uniformity in seed testing and reporting & facilitation in establishment of ISTA accredited laboratories. High performance phenotyping and second generation imaging technologies (Vision 2050, 2015) are few areas which can address quality related aspects.

Seed Quality Enhancement

Intellicoat Technology:

Polymer-based technology used for controlling the time of seed germination through seed coating. It is based on the Intelimer polymers, which differ from other polymers in that they can be customized to abruptly change their physical characteristics when heated or cooled through a pre-set temperature switch. By coating the seeds with Intelimer polymers that have required pre-set temperature switch mechanism, the time of germination of the coated seeds can be adjusted and the synchronization problem of parental lines in hybrid seed production could be prevailed over. Besides, this technology also helps in relay cropping system.

Cold Plasma Coating:

Seeds could be coated with different (hydrophobic/hydrophilic) gaseous polymers under high energy and low temperature. Under such conditions the gases attain the plasma state and get coated on the seed surface. Application of this technology has been shown to control the speed of germination.

Molecular Impulse Response (MIR):

It is a non-chemical, energy-based enhancement, which is supposed to provide improved tolerance to different types of abiotic stress effects, often increasing germination, accelerating maturity, and raising yields. MIR uses an extremely low energy electron shower to create a short-term rise in free radical levels inside the cells of seed. This causes the cells natural defense to produce more anti-oxidants, which disable the free radicals and leave the cell with less free radicles and more anti-oxidants than before the process began.

Bioprospecting:

Application of biological agents to crop seeds have focused on root colonizing bacteria, termed rhizobacteria. PGPR (Plant Growth Promoting Rhizobacteria) comprise those rhizobacteria that include beneficial effects on plants during colonization. Benefits of PGPR include promotion of plant growth and biological control of plant diseases. In addition to causing yield increase, often induce early season growth promotion that can be manifested in various forms, including enhanced seedling emergence, increased biomass of roots and/or foliage, and earlier flowering.

Nanotechnology for Seed Quality Enhancement:

Seed treatment with carbon nano tubes (CNTs), array of nano particles (gold/silver/borates) is a whole new field, yet to be fully unraveled. Application of Nanotechnology in seed science research is still at nascent stage, and its full potential is yet to be tapped. Right from designing smart delivery systems (CNTs, nanofibres) loaded with nutrients/PGRs/pesticides for sustained release, dormancy breakdown, longevity enhancement, vigour augmentation, physiological process regulation and molecular modification, that means it is a research realm with infinite boundaries and shall reorient the entire concept of seed enhancement.

Advances in seed quality (vigour) assessment

- CF analyser: Vigour (apart from germination, desiccation tolerance and longevity) is developed during the maturation or ripening stage, chlorophyll presence on seed has a direct link to maturity and can be fast but precisely measured through its fluorescence

- Single seed oxygen consumption technology: Oxygen consumption is directly related to energy production, so this technology gives us a perfect view on the different quality aspects of seeds such as; imbibition time, speed of germination, homogeneity and energy availability during the germination. This system is thus revolutionary in seed testing for basic research and commercial operations alike. It provides fast and accurate measurements of the different germination aspects of a seed lot. In addition, data is more robust and defining than traditional germination tests.
- Under second generation imaging technologies 3D imaging of seedlings with an array of cameras from different angles, point cloud model is used to create a virtual plant model. Based on model, software classifies seedling into different classes (e.g. normal/ abnormal).
- Infrared Thermography can be used to predict whether a quiescent seed will germinate or die upon water uptake. When a dry seed takes up water, the sugar within the seed dissolves, and this process cools the seed down. For example the temperature of a single pea seed falls rapidly by 2 to 3°C. Viable seeds maintain cool temperatures because they break down storage reserves into sugar. Aged seeds also fail to break down their reserves, or can only break them down after a phase of repair, delaying the thermal profile. Such thermal profiles of a seeds can be recorded and analyzed to construct a library of "thermal fingerprints" that allows to distinguish between viable and dead seeds.
- Seed sector has a twofold responsibility in the area of seed health: to deliver sufficiently healthy seed to farmers and seed producers, and to respect international phytosanitary regulations.
- Development of ultramodern seed processing and storage technologies like thermal seed processing facilities (high precision seed protection, high throughput process)

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Research Article
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EFFECT OF ALTERNATE WETTING AND DRYING IRRIGATION ON YIELD AND QUALITY OF *RABI* RICE(*Oryza sativa* L.) UNDER VARIED NITROGEN LEVELS

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ABSTRACT

A field experiment was conducted during r*abi* 2016-17 and 2017-18 at Agricultural Research Institute Main Farm, Rajendranagar, Hyderabad, on a clay loam soil to study the effect of alternate wetting and drying irrigation on *rabi* rice under varied nitrogen levels. The experiment consisted of three irrigation regimes (recommended submergence of 2-5 cm water level as per crop growth stage, AWD irrigation of 5 cm when water level drops to 3 cm in water tube, AWD irrigation of 5 cm when water level drops to 5cm in water tube) as main plot treatments and three nitrogen levels (120, 160 and 200 kg N ha^{-1}) as sub plot treatments laid out in split plot design with three replications. Significant improvement in yield and quality parameters of rice except protein content, amylose content was observed with recommended submergence of 2 to 5 cm water level as per crop growth stage which was on par with AWD irrigation of 5 cm when water level drops to 3 cm in water tube. Among nitrogen levels, application of 200 kg N ha^{-1} resulted in significantly higher yield and quality parameters except hulling percent, milling percent and head rice recovery of *rabi* rice which was on par with application of 160 kg N ha^{-1}.

Rice (*Oryza sativa* (L.)) is one of the most important staple food crops 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 (43.50 million ha) and it is the second largest producer (163.51 million tonnes) of rice next to China (203.14 million tonnes) with an average productivity of 3.76 t ha^{-1}, though increasing marginally, but is still well below the world's average yield of 4.51 t ha [1] (www.ricestat.irri.org). In India, Telangana State is a key rice producing state with 10.46 lakh hectares with a production of 30.47 million tonnes (DoES, 2017). A huge amount of water is used for the rice irrigation under the conventional water management in lowland rice termed as "continuous deep flooding irrigation" consuming about 70 to 80 per cent of the total irrigated fresh water resources in the major part of the rice growing regions in Asia including India (Bouman and Tuong, 2001). Future predictions on water scarcity limiting agricultural production have estimated that by 2025, about 15-20 million ha of Asia's irrigated rice fields will suffer from water shortage in the dry season especially since flood irrigated rice uses more than 45 % of 90 % of total freshwater used for agricultural purposes. Generally, rice consumes about 3000-5000 litres of water to produce one kg of rice, which is about two to three times more than to produce one kilogram of other cereals such as wheat or maize. Therefore, there is need to develop and adopt water saving methods in rice cultivation so that production and productivity levels are elevated despite the looming water crisis.

However, rice is very sensitive to water stress. Attempts to reduce water in rice production may result in yield reduction and may threaten food security. Several water-efficient irrigation strategies had been tested, advanced, applied and spread in different rice growing regions. Among these, important water-saving technique is alternate wetting and drying (AWD). AWD is an irrigation technique where water is applied to the field a number of days after disappearance of ponded water. This means that the rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice growing stage. The AWD irrigation aims in reducing water input and increasing water productivity while maintaining grain yield (Bouman and Tuong, 2001). Singh *et al.* (1996) reported that, in India, the AWD irrigation approach can reduce water use by about 40–70 per cent compared to the traditional practice of continuous submergence, without a significant yield loss. The water availability in Telangana is limited during the r*abi* season thereby paddy is subjected to water stress. Alternate Wetting and Drying (AWD) is a suitable water saving irrigation technique.

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Among nutrients, nitrogen is the most important limiting element in rice growth (Jayanthi *et al.*, 2007). Limitation of this nutrient in the growth period causes reduction of dry matter accumulation and prevents grain filling and therefore increases the number of unfilled grains. Rice shows excellent response to nitrogen application, but the recovery of applied nitrogen is quite low approximately 31-40% (Cassman *et al.*, 2002).

Both water and nitrogen are most important inputs in rice production. The behaviour of soil nitrogen under wet soil conditions of lowland rice is markedly different from its behavior under dry soil conditions. Under flooded conditions, most nitrogen to be taken up by rice is in ammonium form. The practice of AWD results in periodic aerobic soil conditions, stimulating sequential nitrification and denitrification losses (Buresh and Haefele, 2010). Growing rice under AWD could consequently lead to a greater loss of applied fertilizer and soil nitrogen compared with that under submergence conditions. Water and nutrients may interact with each other to produce a coupling effect. Furthermore, if an interaction exists between water management practice and nitrogen rate, then the N input will have to be changed under AWD. In this context, the present study is undertaken to study the effect of alternate wetting and drying irrigation under varied nitrogen levels on r*abi* Rice.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Institute Main Farm, Rajendranagar, Hyderabad, situated in Southern Telangana Zone of Telangana state at $17^0$19' N Latitude, $78^0$23' E Longitude with an altitude of 542.3 m above mean sea level. The soil of the experimental field was clay loam in texture, moderately alkaline in reaction, non-saline, low in organic carbon content, low in available nitrogen (N), medium in available phosphorous (P_2O_5) and potassium (K_2O). The experiment consisted of three irrigation regimes (I) [(recommended submergence of 2 to 5 cm water level as per crop growth stage (I_1), AWD irrigation of 5 cm when water level drops to 3cm in water tube (I_2), AWD irrigation of 5cm when water level drops to 5 cm in water tube (I_3)) as main plot treatments and three nitrogen levels (N) [(120 kg N ha^{-1} (N_1), 160 kg N ha^{-1} (N_2) and 200 kg N ha^{-1} (N_3)] as sub plot treatments, laid out in split plot design with three replications. Nitrogen was applied in the form of urea in three equal splits *viz.,* 1/3rd as basal, 1/3rd at active tillering stage and 1/3rd at panicle initiation stage. A uniform dose of 60 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied where entire phosphorus was applied as basal in the form of single super phosphate whereas, potassium was applied in the form of muriate of potash in two equal splits *viz.,* as basal and top dressing at panicle initiation stage. The rice variety KNM-118 was transplanted with 30 days old seedlings at a spacing of 15 cm X 15 cm @ 2 seedlings per hill^{-1}. The conventional flooding irrigation practice was followed in all the treatments till 15 days after transplanting for proper establishment of the crop and after that, the irrigation schedules were imposed as per the treatment requirements with the help of field water tube. The field water tube was made of plastic pipe having 40 cm length and 15 cm in diameter so that the water table is easily visible. The field tube also contains perforations of 0.5 cm in diameter and 2 cm apart, so that water can flow readily in and out of the tube. The field tube was hammered in to the soil in each net plot such that 15 cm protrudes above the soil surface. After installation, the soil from inside the field tube was removed so that the bottom of the tube is visible. Irrigation was applied to re flood the field to a water depth of 5 cm when the water level in the field tube dropped to a threshold level of about 3 or 5 cm as per the treatment. Irrigation was withheld 10 days ahead of harvest. The size of the gross net plot size of 6.0 m × 4.0 m and net plot size of 5.4 m × 3.4 m was adopted in field experiment. The plants from each net plot were harvested separately, sun dried, threshed, winnowed, and cleaned. Thus obtained grain yield from each net plot area was weighed at 14% moisture content and expressed as kg ha^{-1}.

Hulling percentage was determined using Satake dehuller, milling percentage with Satake polisher, head rice recovery through rice grader, while grain protein content was determined according to AOAC (1994) and amylose content was calculated as per method described by Juliano (1971). The weeds were managed using pre-emergence application of the recommended herbicide *i.e* Oxadiargyl @ 87.5 g ha^{-1} dissolved in water and mixed with soil and broadcasted uniformly 3 days after transplanting maintaining a thin film of water in the field and followed by one hand weeding at 35 days after transplanting. The data on various parameters studied during the course of investigation were statistically analyzed as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Grain and Straw yield

Irrigation maintained at recommended submergence of 2-5 cm water level as per crop growth stage (I_1) registered significantly higher grain and straw yield during both the years. However, the grain yield recorded in AWD irrigation of 5 cm when water level falls below 3 cm from soil surface in perforated pipe (I_2) was found to be statistically at par with the treatment recommended submergence of 2-5 cm water level as per crop growth stage (I_1) and both of these treatments produced significantly superior grain and straw yield compared to AWD irrigation of 5 cm when water level falls below 5 cm from soil surface in perforated pipe(I_3). This might be due to favorable vegetative growth and development as they received adequate and sufficient moisture at proper amount and critical stages during entire period of growth since water plays a vital role in the carbohydrate metabolism, protein synthesis, cell division, cell enlargement and partitioning of photosynthates to sink for improved development of growth traits. Water stress soon after panicle initiation reduces the number of spikelet primordia that develop. Hence, plants were unable to extract more water and nutrients from deeper layers of soil under moisture deficit conditions which ultimately led to poor growth and yield attributes. Nitrogen levels had a profound influence on the grain and straw yield of rice during both the years. Maximum grain and straw yield was registered with the application of 200 kg N ha^{-1} and was at par with the application of 160 kg N ha^{-1} during both the years. Significantly less grain and straw yield was obtained with the application of 120 kg N ha^{-1} compared to the application of 200 kg N ha^{-1} and 160 kg N ha^{-1} during both the years. These results are in conformity with the findings of Babu *et al*. (2013).

Application of higher levels of nitrogen made nitrogen more available for plant uptake thus promoting growth such as plant height, number of tillers and dry matter production. Finally, the adequate supply of nitrogen according to crop needs might have resulted in to a more vigorous and extensive root system of crop leading to increased vegetative growth and means of more efficient sink formation and greater sink size, greater carbohydrate translocation from vegetative plant parts to the grains ultimately reflected in higher grain yield in 160 and 200 kg N ha^{-1} treatments as reported by Anil *et al*. (2014).

Quality parameters

Irrigation maintained at recommended submergence of 2-5 cm water level as per crop growth stage (I_1) registered significantly higher milling percentage, head rice recovery of rice during both the years. However, the milling percentage, head rice recovery of rice with AWD irrigation of 5 cm when water level falls below 3 cm from soil surface in perforated pipe (I_2) was found to be statistically at par with the treatment recommended submergence of 2-5 cm water level as per crop growth stage (I_1) and both of these treatments were superior as compared to AWD irrigation of 5 cm when water level falls below 5 cm from soil surface in perforated pipe(I_3). This might be due to favorable vegetative growth and development as they received adequate and sufficient moisture at proper amount and critical stages during entire period of growth. However, hulling percentage, protein and amylose content in rice were not significantly influenced by irrigation regimes.

Among the nitrogen levels, significantly higher grain protein content and amylose contents were recorded with application of 200 kg N ha^{-1} which was however on par with 160 kg N ha^{-1} during both the years. Nitrogen is an integral part of proteins and its increased application resulted in increased protein content in milled rice. Similar results were obtained by Ray *et al.*(2015). However, nitrogen levels did not influence hulling and milling percentage and head rice recovery of rice during both the years. The interaction effect of irrigation regimes and nitrogen levels on grain, straw yield and quality parameters of rice during both the years and in pooled means was found to be non significant.

CONCLUSIONS

Based on the research results, it can be concluded that recommended submergence of 2-5 cm water level as per crop growth stage (I_1) recorded significantly higher grain and straw yields, milling percentage and head rice recovery of rice which was on par with AWD irrigation of 5 cm when water level

Table 1. Grain and Straw yield (kg ha^{-1}) of rice as influenced by alternate wetting and drying irrigation and nitrogen levels during *rabi* 2016, 2017 and pooled means

Treatments	Grain yield (kg ha^{-1})			Straw yield(kg ha^{-1})		
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**
Irrigation regimes (I)						
I_1- 2-5cm submergence as per crop stage	7026	7221	7123	7936	8153	8045
I_2- AWD irrigation of 5 cm with 3 cm fall in field water tube	6925	7150	7037	7844	8056	7956
I_3- AWD irrigation of 5 cm with 5 cm fall in field water tube	6414	6652	6533	7333	7545	7439
S.Em±	54.0	60.4	55.2	52.8	52.1	52.4
C.D. at 5%	150	168	153	147	145	146
Nitrogen levels (N)						
N_1-120 kg ha^{-1}	6706	6922	6814	7605	7817	7711
N_2-160 kg ha^{-1}	6802	7021	6911	7710	7921	7816
N_3-200 kg ha^{-1}	6857	7081	6969	7798	8016	7907
S.Em.±	37.2	44.5	39.0	41.0	41.1	41.0
C.D. at 5%	81	97	85	89	89	89
Interactions	NS	NS	NS	NS	NS	NS

Table 2. Hulling and milling percentage (%) of rice as influenced by alternate wetting and drying irrigation and nitrogen levels during *rabi* 2016, 2017 and pooled means

	Hulling (%)			Milling (%)		
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**
Irrigation regimes (I)						
I_1- 2-5cm submergence as per crop stage	80.8	81.0	80.9	67.5	67.4	67.4
I_2- AWD irrigation of 5 cm with 3 cm fall in field water tube	80.7	80.9	80.8	67.3	67.2	67.3
I_3- AWD irrigation of 5 cm with 5 cm fall in field water tube	80.5	80.7	80.6	67.0	66.8	66.9
S.Em±	0.1	0.2	0.2	0.2	0.2	0.2
C.D. at 5%	NS	NS	NS	0.4	0.5	0.5
Nitrogen levels (N)						
N_1-120 kg ha^{-1}	80.7	80.8	80.8	67.2	67.4	67.3
N_2-160 kg ha^{-1}	80.6	80.8	80.7	67.3	67.3	67.3
N_3-200 kg ha^{-1}	80.7	80.9	80.8	67.2	67.0	67.1
S.Em.±	0.1	0.1	0.1	0.6	0.2	0.4
C.D. at 5%	NS	NS	NS	NS	NS	NS
Interactions(IxN)	NS	NS	NS	NS	NS	NS

Table 3. Head rice recovery (%), Grain protein content and amylose (%) of rice as influenced by alternate wetting and drying irrigation and nitrogen levels during *rabi* 2016, 2017 and pooled means

	Head rice recovery (%)			Grain protein content (%)			Amylose(%)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Irrigation regimes (I)									
I_1- 2-5cm submergence as per crop stage	65.06	65.12	65.09	9.18	9.14	9.16	23.9	25.0	24.5
I_2- AWD irrigation of 5 cm with 3 cm fall in field water tube	63.95	63.87	63.91	9.07	9.04	9.06	23.8	24.7	24.2
I_3- AWD irrigation of 5 cm with 5 cm fall in field water tube	63.32	63.34	63.33	9.03	8.98	9.01	23.4	24.3	23.9
S.Em±	0.20	0.23	0.21	0.04	0.05	0.04	0.44	0.45	0.44
C.D. at 5%	0.57	0.64	0.60	NS	NS	NS	NS	NS	NS
Nitrogen levels (N)									
N_1-120 kg ha^{-1}	63.93	63.98	63.95	8.94	8.90	8.92	23.0	23.9	23.5
N_2-160 kg ha^{-1}	64.16	64.04	64.10	9.16	9.11	9.13	24.0	24.6	24.3
N_3-200 kg ha^{-1}	64.23	64.31	64.27	9.20	9.16	9.18	24.1	24.6	24.4
S.Em.±	0.14	0.16	0.15	0.04	0.04	0.04	0.23	0.19	0.21
C.D. at 5%	NS	NS	NS	0.10	0.09	0.09	0.75	0.5	0.63
Interactions(IxN)	NS	NS	NS	NS	NS	NS	NS	NS	NS

falls below 3 cm from soil surface in perforated pipe (I_2). This indicates that the water in AWD irrigation regimes can be allowed to drop to levels of 3 cm below ground level in field water tube by delaying irrigation for 2 to 3 days before reflooding. Among nitrogen levels, application of 200 kg N ha^{-1} recorded significantly higher grain and straw yields, protein content and amylose contents of grain which was however on par with application of 160 kg N ha^{-1} .

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Research Article
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A NON-DESTRUCTIVE SEED SAMPLING METHOD FOR HIGH THROUGHPUT GENOTYPING IN GROUNDNUT

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ABSTRACT

The routine isolation of plant genomic DNA uses leaf tissues for genotyping in Marker Assisted Selection (MAS). This requires time and resources for planting the segregating material, logistics of labeling and sampling in the field and harvesting the selected plants. We describe here a simple, non-destructive sampling method for genomic DNA isolation from a mature dry groundnut seed. For the comparative study, the leaf disc and seed chips of 46 genotypes were sent to Intertek Pvt. Ltd for DNA isolation and genotyping. The DNA isolation yielded a mean concentration of 16.8 ng/µl and 31.8 ng/µl from seed and leaf tissues, respectively with A260/A280 ratio of 1.9 (mean) for both the samples. The isolated DNA was genotyped using the Kompetitive allele-specific PCR assay with 10 SNPs associated with resistance to late leaf spot, rust, and high oleic acid. The KASP assay resulted in a 97% allele calls in the DNA isolated from seed and leaf tissues. The quality of DNA isolated from seed chips was functionally comparable to DNA extracted from leaf disc which gave the similar results in KASP assay. This method is non-destructive and useful for MAS to screen segregating population for targeted traits prior to planting which enables to minimize resources.

In groundnut, the improvements for foliar fungal disease resistance i.e. rust and late leaf spot (LLS) and oil quality are among the most priority traits for breeders. The availability of cost-effective and reliable molecular marker facilitates the plant breeders to deploy marker-assisted selection (MAS) simultaneous improvement of one or more target trait based on genotype. The earlier studies suggested that a major quantitative trait locus (QTL) for rust and two major QTLs for LLS resistance using the recombinant inbred line (RIL) population derived from a cross between TAG 24 × GPBD 4 (Khedikar *et al.* 2010; Sujay *et al.* 2012; Kolekar *et al.* 2016). These QTL mapping laid the foundation for user-friendly SSR markers in marker-assisted selection (MAS) in groundnut for particularly foliar fungal disease resistance. MAS can be used as a tool of choice when it comes to the complex traits like LLS and rust as disease screening is season dependent and breeding cycle often delayed to later generations to get reliable disease score. Molecular markers are being widely used for identification, screening, and selection of LLS and rust resistance QTLs in many groundnut cultivar improvement programs *viz*., ICGV 91114, JL 24 and TAG 24 (Varshney *et al.* 2014), TMV 2 and JL 24 (Yeri *et al.* 2014), TMV 2 (Kolekar *et al.* 2017). SSR makers were used to select resistance to LLS and rust to develop breeding lines that combine earliness and disease resistance in the genetic background of TAG 24, ICGV 91114 and JL 24 (Janila *et al.* 2016a).

In the context of oil quality, the higher oleic acid and lower linoleic acid content are desirable for consumer preference and for the longer shelf life of groundnut kernels and its derived products. The identification of natural mutant, F435 (~80% oleic acid) (Norden *et al.* 1987), which lacks functional fatty acid desaturase (FAD) enzyme was breakthrough in groundnut breeding to breed high oleic acid and reduced linoleic acid content in kernels. Sequencing of these FAD alleles has led to the identification of mutations (substitution from G:C '! A:T in the A-genome; A:T insertion in the B-genome). The allele-specific and Cleaved Amplified Polymorphic Sequences (CAPS) markers were developed differentiating mutant and wild-type alleles of *ahFAD2A* and *ahFAD2B*. These markers are successfully used in groundnut breeding programs across the globe to select mutant *ahFAD2A* and *ahFAD2B* alleles to develop high oleic lines (Chu *et al.* 2011; Mienie and Pretorius, 2013; Xiuzhen *et al.* 2016; Janila *et al.* 2016b; Bera *et al.* 2018). Even though gel-based SSRs, allele-specific and CAPS markers are accurate and expedite many breeding programs, it holds certain limitations such as time-consuming, tedious and laborious.

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The entire genome of groundnut progenitors *A. duranensis* and *A. ipaensis* has been sequenced and analyzed (Bertioli *et al.* 2016). This paved the way for development and utilization of sequence information for high throughput genotyping. The development of PCR/ array-based SNP genotyping protocols has ployed to analyze single nucleotide polymorphisms (SNP) markers quickly and accurately. Additionally, improvements in laboratory automation have increased the capacity of MAS, enabling high-throughput sample screening, and thus save the time required to breed new cultivar (Desmae *et al.* 2018). Recently, QTL sequencing (QTL-seq) strategy was deployed to map genomic regions associated with resistance to LLS and rust in groundnut. This study developed 26 diagnostic SNPs derived from earlier mapped QTLs on linkage group A03 for LLS and rust resistance (Pandey *et al.* 2017). Based on identified mutations in *ahFAD2A* and *ahFAD2B* alleles, the diagnostic SNPs were constructed at ICRISAT and shared with Intertek Pvt Ltd, Hyderabad for initial testing and validation in Kompetitive allele-specific PCR (KASP). The initial standardization and wet-lab validation of KASP assay come up with a diagnostic SNP marker for *ahFAD2B* allele; four SNPs for rust and five SNPs for LLS. Groundnut breeding program at ICRISAT perated small leaf disc (2 mm) samples for KASP assay to genotype large number of breeding population with 10 diagnostic SNP for high oleic acid, rust, and LLS resistance.

The routine MAS program uses leaf tissues for the DNA isolation followed by genotyping on gel-based and/or high throughput platforms. Such MAS program uses a relatively small number of markers across relatively large numbers of individuals, lines, families, or populations. DNA needs to be extracted from a large number of leaf samples for genotyping on gel-based and/or high throughput platforms. The isolation of DNA from leaf tissues (Doyle and Doyle, 1987) is common in various crops and works well to utilize DNA for various genotyping platforms. But the leaf tissue based sampling for genotyping demands logistics to grow plants in field or glasshouse, and agronomic management, labeling and sampling. Utilization of seed chips based sampling DNA extraction and genotyping holds the advantage of being quick, independent of growing season, and saves the resources and time to grow the plants. In the present study, an attempt has been made to utilize the mature groundnut seed chip method to isolate genomic DNA, verification of seed DNA for yield and quality and its effectiveness for PCR analysis in comparison with the leaf isolation method.

MATERIALS AND METHODS

A total of 46 representative groundnut genotypes (Table 1) comprising of advanced breeding lines and released cultivars were utilized in the present study. Thirty-nine entries represent high oleic acid lines (>75% oleic acid content) and seven entries (S. No. 40-46) represent normal oleic acid lines (<50) (Table 1). Seeds of these genotypes were sown on experimental plots of Alfisols at ICRISAT, Patancheru, India (at 17.53 æ%N latitude and 78.27 æ%E) during the rainy season of 2018 (July-October). Leaf tissues obtained from three-week-old seedlings were used for DNA isolation. The seeds samples of the same 46 representative genotypes were used for seed chip DNA isolation. A small piece (0.02 g/seed) was cut from the distal end of the seed carefully without disturbing the embryo. The leaf and seed tissues were placed in 12 × 8-well strip tube with strip cap (Marsh Biomarket, USA) in a 96 well plate. The DNA was isolated using sbeadex™ (surface-coated superparamagnetic beads) along with Kleargene™ (spin columns) and steps were followed according to the specifications of the manufacturer facility available at Intertek Pvt. Ltd., Hyderabad. The quality of DNA sample extracted from seed and leaf tissue was verified by spectrophotometry using Nano Drop (Shimadzu UV160A, Japan). The isolated DNA was utilized to assay 10 SNPs (one SNP for *ahFAD2B*, four SNPs for LLS and five SNPs for rust) using KASP™ genotyping platform.

Table 1. List of genotypes used for leaf and seed sampling

S. No.	Genotype ID
1.	ICGV 15016
2.	ICGV 15064
3.	ICGV 16013
4.	ICGV 16017
5.	ICGV 16030
6.	ICGV 16035
7.	ICGV 16045
8.	ICGV 16668

S. No.	Genotype ID
9.	ICGV 16687
10.	ICGV 16700
11.	ICGV 16701
12.	ICGV 171011
13.	ICGV 16686
14.	ICGV 171007
15.	ICGV 171023
16.	ICGV 171027
17.	ICGV 171006
18.	ICGV 16667
19.	ICGV 16698
20.	ICGV 171017
21.	ICGV 171015
22.	ICGV 16020
23.	ICGV 171051
24.	ICGV 171040
25.	ICGV 171039
26.	ICGV 171046
27.	ICGV 171041

S. No.	Genotype ID
28.	ICGV 171048
29.	ICGV 171026
30.	ICGV 171004
31.	ICGV 171021
32.	ICGV 171019
33.	ICGV 171024
34.	ICGV 171016
35.	ICGV 171009
36.	ICGV 171018
37.	ICGV 171025
38.	ICGV 171020
39.	ICGV 171002
40.	ICGV 03043
41.	ICGV 07222
42.	ICGV 07220
43.	ICGV 00350
44.	ICGV 00351
45.	ICGV 02266
46.	ICGV 91114

RESULTS AND DISCUSSION

The quality of each extracted DNA from seed and leaf tissue was verified spectrophotometrically using NanoDrop for the detection of contaminants such as protein, salts, and polysaccharides. High-quality genomic DNA was comparable to the leaf tissues could be isolated from groundnut seeds using the seed chip method (Table 2). The isolated DNA from 46 seed samples yielded a mean concentration of 16.8 ng/µl DNA per extraction with a mean A260/A280 ratio of 1.9. The highest seed DNA yield was obtained from the genotype, ICGV 171039 with a concentration of 35 ng/µl. The groundnut leaf yielded a mean of 31.8 ng/µl of DNA per extraction with an average A260/A280 ratio of 1.9. The purity of the extracted DNA and minimal contamination by polysaccharides and phenolic compounds was confirmed by A260/A280 nm ratio of around 1.8. The obtained quantity of seed DNA (mean 16.8 ng/µl) is sufficient to conduct about four PCR reactions.

In order to evaluate the efficiency, reliability, and quality of the DNA extracted from the leaf and seed of groundnut genotypes KASP genotyping assay was utilized. The KASP assay mix contains the allele-specific primers for three traits in groundnut *viz.*, LLS, rust, and high oleic acid content (*AhFAD2B*) allele. The allele-specific primers each harbored a unique tail sequence that corresponds with a universal fluorescence resonant energy transfer (FRET) cassette. The wild-type allele of *AhFAD2B* was labeled with FAM™ dye whereas the mutant allele of *AhFAD2B*-gene was labeled with HEX™ dye. Bi-allelic discrimination was achieved through the competitive binding of these two allele-specific primers. If a genotype at a given SNP was homozygous for wild-type allele, only FAM fluorescent signal was generated. However, HEX™ fluorescent signals were generated if the respective genotypes have mutant alleles of *AhFAD2B* gene. The SNP marker, snpAH0002 showed A:A and A:_ base combination for mutant allele in the homozygous and heterozygous states, respectively (Table 3). The wild-type *AhFAD2B* allele was represented as null [-:-]. Similarly, the FAM and HEX™ fluorescent dyes were used to differentiate susceptible and resistance alleles for LLS and rust, respectively. This assay considers the quantitative metrics such as call rate and sensitivity to differentiate the tested genotypes among the population for zygosity and presence/absence of target alleles.

Table 2. DNA concentration and purity obtained from genomic DNA of groundnut leaf disc and seed chip (*OD: Optical density measured by NanoDrop™)

S. No.	Genotype	Leaf disc		Seed chips	
		Concentration (ng/µl)	DNA Purity* (A260/A280)	Concentration (ng/µl)	DNA Purity* (A260/A280)
1	ICGV 171051	33.6	2.0	14.5	2.0
2	ICGV 171048	43.5	2.0	17.3	1.7
3	ICGV 171046	92.3	1.7	28.4	1.5
4	ICGV 171041	49.9	2.0	13.7	1.9
5	ICGV 171040	36.5	1.8	24.0	1.9
6	ICGV 171039	26.2	1.7	35.0	2.1
7	ICGV 171027	25.2	2.0	9.7	2.0
8	ICGV 171026	27.3	2.0	6.2	2.3
9	ICGV 171025	29.7	1.9	29.5	2.1
10	ICGV 171024	32.1	2.0	21.6	2.1
11	ICGV 171023	36.7	2.0	7.1	2.1
12	ICGV 171021	25.1	1.9	13.5	1.9
13	ICGV 171020	30.2	2.1	22.2	1.9
14	ICGV 171019	69.9	1.6	14.0	2.0
15	ICGV 171018	50.4	2.0	17.3	1.9
16	ICGV 171017	18.8	1.9	15.0	1.9
17	ICGV 171016	15.8	2.1	15.6	1.9
18	ICGV 171015	25.0	2.0	18.3	2.1
19	ICGV 171011	41.3	1.9	28.1	1.8
20	ICGV 171009	23.1	1.9	20.5	2.0
21	ICGV 171007	26.9	1.9	10.6	2.1
22	ICGV 171006	20.3	1.8	14.1	2.1
23	ICGV 171004	17.6	2.2	17.8	2.0
24	ICGV 171002	29.3	2.0	21.7	1.8
25	ICGV 16701	33.7	1.9	10.4	2.1
26	ICGV 16700	25.6	2.1	5.9	2.2
27	ICGV 16698	24.3	2.1	18.2	1.9
28	ICGV 16687	41.7	1.9	7.6	2.4
29	ICGV 16686	24.5	1.7	16.6	1.6
30	ICGV 16668	43.8	1.9	19.1	1.8
31	ICGV 16667	21.5	2.1	13.2	1.7
32	ICGV 16045	34.8	2.1	11.3	1.8
33	ICGV 16035	18.6	2.0	4.8	2.2
34	ICGV 16030	25.1	1.8	6.2	2.1
35	ICGV 16020	0.6	1.4	24.8	2.1

S. No.	Genotype	Leaf disc		Seed chips	
		Concentration (ng/µl)	DNA Purity* (A260/A280)	Concentration (ng/µl)	DNA Purity* (A260/A280)
36	ICGV 16017	28.4	1.9	12.5	1.7
37	ICGV 16013	15.7	2.0	13.8	1.4
38	ICGV 15064	34.7	1.9	26.7	1.7
39	ICGV 15016	39.5	1.9	13.3	2.1
40	ICGV 07222	28.6	2.0	27.6	1.8
41	ICGV 07220	38.1	1.9	11.0	1.8
42	ICGV 03043	36.0	2.0	10.7	1.7
43	ICGV 02266	44.8	2.0	23.0	1.8
44	ICGV 00351	27.5	2.0	27.0	2.0
45	ICGV 00350	30.9	2.1	17.6	1.7
46	ICGV 91114	17.4	2.2	27.9	1.9

The reactions produced for each genotype with both seed and leaf DNA was compared and the result indicated a good allele call between both sets, except for three individuals (ICGVs 16700, 171002 and 171006). A summary of the calls is provided in Table 3. The SNPs studied in this experiment produced polymorphic results among LLS and rust resistant and susceptible genotypes. The KASP assay was performed with 10 SNP markers in 46 genotypes. The current assay (901 out of 940 SNP calls) operated with good efficiency with a call rate of 97% and includes 19 alleles that were scored with the unknown; 20 alleles as uncallable.

In summary, we report a simple sampling procedure for non-destructive DNA extraction of individual groundnut seeds followed by comparative study with leaf DNA by using KASP-based genotyping. The extraction method is cost-effective and time-efficient to use on a large scale, and are reliable enough for a large breeding population. In the current sampling set-up, we used a small box of 94 cases for a given seed lot and thereby maintaining a unique plate identity for the genotyping. Once the genotypic results are obtained, the selection is operated tracing back to seed box and seed based selection/ rejection of individuals is done based on genotypic results. This reduces the efforts of labeling of individual seeds and maintains the fidelity through the process of sampling, genotyping and selection. These results could assist plant breeders in fine-tuning their tissue sampling procedure through molecular breeding.

Table 3. Comparative SNP profile obtained from genomic DNA of groundnut leaf disc and seed chip

DNA \ Assay	SNP for high oleic acid	SNPs for late leaf spot				SNPs for rust				
	snpAH0002	snpAH0004	snpAH0005	snpAH0010	snpAH0011	snpAH0015	snpAH0017	snpAH0018	snpAH0021	snpAH0026
ICGV 15064_Leaf	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 15064_Seed	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16687_ Leaf	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16687_ Seed	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16698_ Leaf	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16698_ Seed	A:A	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16700_ Leaf	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:T	C:C
ICGV 16700_ Seed	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 00351_ Leaf	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 00351_ Seed	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 02266_ Leaf	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 02266_ Seed	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 03043_ Leaf	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 03043_ Seed	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 07222_ Leaf	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 07222_ Seed	-:-	C:C	G:G	C:C	C:C	T:T	A:A	G:G	C:C	G:G
ICGV 16701_ Leaf	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 16701_ Seed	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 171002_ Leaf	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 171002_ Seed	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:T	G:G	C:C
ICGV 171004_ Leaf	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 171004_ Seed	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 171006_ Leaf	A:A	G:G	C:G	A:A	T:T	A:A	C:C	A:A	G:G	C:C
ICGV 171006_ Seed	A:A	G:G	C:C	A:A	T:T	A:A	C:C	A:A	G:G	C:C

-:- Null allele

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YIELD AND YIELD ATTRIBUTES OF RICE (*Oryza sativa* L.) AS INFLUENCED BY FOLIAR APPLICATION OF ZINC OXIDE NANOPARTICLES UNDER DIFFERENT CROP ESTABLISHMENT METHODS

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ABSTRACT

A field experiment was conducted during *rabi*, 2015-16 and 2016-17 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad to study the effect of nano zinc oxide foliar application in rice under different crop establishment methods. The experiment was laid out in split plot design with two establishment methods (direct seeding through dibbling under puddled condition and normal transplanting) in main plots and six nutrient management practices (Absolute control-no fertilizer, control-RDF NPK, RDF + soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}, RDF + two foliar sprays of $ZnSO_4.7H_2O$ at 0.5%, RDF + two foliar sprays of nano ZnO at 1000 ppm and RDF + two foliar sprays of nano ZnO at 1500 ppm) in sub-plots with four replications. The results revealed that number of panicles m^{-2} were significantly higher in direct seeded rice as compared to normal transplanting but other yield attributes like panicle length, panicle weight and filled grains panicle^{-1} were significantly more in normal transplanted rice. Direct seeded rice recorded significantly higher grain yield (9.84, 8.85 and 9.45% during 2015, 2016 and pooled mean, respectively) as compared to normal transplanting. Among nutrient management practices, RDF + two foliar sprays of nano ZnO at 1000 ppm being at par with RDF + two foliar sprays of $ZnSO_4.7H_2O$ at 0.5% and RDF + two foliar sprays of nano ZnO at 1500 ppm produced higher yield attributes i.e. number of panicles m^{-2}, panicle length, panicle weight, grains panicle^{-1}, test weight and grain and straw yield compared to other nutrient management practices.

Rice is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of human population of the planet. Rice occupies approximately 160 million ha area globally, of which 134 million ha is in Asia. World rice production is 741 million tonnes with an average productivity of 4631 kg ha^{-1} (FAOSTAT, 2018). India is the second largest producer after China and has an area of about 42.96 million ha and production of 112.91 million tonnes with the productivity of 2628 kg ha^{-1} (DoES, 2018). In Telangana state, it is cultivated in an area of 1.41 million ha with production and productivity of 4.54 million tonnes and 3211 kg ha^{-1}, respectively (BoES, 2015).

Traditionally rice is established by transplanting seedlings in puddled soils, which demands a huge amount of water and labour. In the present looming scenario of scarcity of water and labour due to population explosion and urbanization which poses a serious threat to sustainability of traditional methods of rice production, there is an urgent need to replace conventional transplanting method of rice by more resource saving crop establishment method of rice like direct seeding of rice (DSR). Under the DSR technology sowing of rice seeds is done directly in the soil rather than transplanting seedlings.

The productivity of rice soil depends upon the adequate and balanced nutrition of all essential nutrients including the micronutrients. In rice, continuous use of NPK fertilizer has remarkably increased production but simultaneously brought about problems related to micronutrient deficiencies, particularly that of zinc (Zn) in soil. Rice, one of the world's most important cereal crops is affected by Zn deficiency. At least 70 % of the rice crop is produced in flooded conditions resulting in increment in phosphorus and bicarbonate concentration which reduces soil Zn availability to the crop. About 50 % paddy soils in the world are Zn deficient with 35 % in Asia alone (Cakmak, 2008). In an Indian scenario, around 49 % soils from all the main agricultural areas are deficient in Zn (Naik and Das, 2008).

Zinc is one of the essential nutrients required for plant growth. Its important role can be adjudged as it controls the synthesis of Indole acetic acid (IAA), a phytohormone which dramatically regulates the plant growth. It is also necessary for the chlorophyll synthesis and carbohydrate formation. As Zn is the structural

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component of phosphorous (P)-mobilizing phosphatase and phytase enzymes, it can be hypothesized that application of nano ZnO may help in more secretion of P-mobilizing enzymes, which is involved in native P mobilization for plant nutrition from unavailable organic sources (Tarafdar and Claassen, 2003).

Hence, Zinc (Zn) is one of the important micronutrients required for plant growth and development. Soil Zn deficiency is a major problem and hence adequate Zn supply during crop developmental stages are recommended to improve the nutrient content in the rice grain and also improve productivity of the soil. Crops require only small amount of Zn for their normal growth but its application rate is high due to very low fertilizer use efficiency which vary 1-3 and 5-8% in soil and foliar application, respectively. Hence, there is a need to have formulations of Zn with improved use efficiency for the better crop performance with less input.

Nano fertilizers are synthesized in order to regulate the release of nutrients depending on the requirements of the crops, and it is also reported that nano fertilizers are more efficient than ordinary fertilizer (Suman *et al.*, 2010). In recent past, the positive effect of nano fertilizers on germination, photosynthesis, growth, nutrient absorption, fertilizer use efficiency and yield have been studied in various crops under pot culture and field studies. Keeping these points in consideration, the experiment was carried out to study the effect of zinc oxide nano particles foliar application on yield and yield attributes of rice (*Oryza sativa* L.) under different crop establishment methods.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2015-16 and 2016-17 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad. The initial soil parameters were pH=8.1; EC= 0.28 dS m^{-1}; organic carbon = 0.46%; available nitrogen = 229.0 kg ha^{-1}; available P = 21.9 kg ha^{-1}; available K= 399.0 kg ha^{-1}; available zinc = 0.68 and available iron= 6.40 ppm. The analysis of soil sample revealed that soil was clay loam in texture having low organic carbon and available nitrogen, medium in available phosphorus and high in available potassium contents with moderately alkaline in reaction. The available zinc and iron content were sufficient. Rice variety varadhan (DRR Dhan 36) is tested in the experiment.

The experiment was laid out in split plot design with two crop establishment methods (DSR-direct seeding through hand dibbling under puddled condition and NTP- normal transplanting) in main plots and six nutrient management practices (Absolute control-no fertilizer, control-RDF NPK, RDF + soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}, RDF + two foliar sprays of $ZnSO_4.7H_2O$ @ 0.5%, RDF + two foliar sprays of nano ZnO @ 1000 ppm and RDF + two foliar sprays of nano ZnO @ 1500 ppm) in sub-plots with four replications. The recommended dose of fertilizer (RDF) for rice is 120, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1} respectively. Nitrogen was applied in three equal split doses i.e. basal, 45 DAS and 75 DAS in direct seeded rice and basal, 30 DAT and 60 DAT under normal transplanting, respectively. Full dose of P, K and Soil Zn were applied as basal dose. The nutrients N, P_2O_5 and K_2O were supplied through urea, single super phosphate and muriate of potash, respectively. The foliar application of zinc shall be carried out at two stages i.e. 15 DAT and 25 DAT in transplanted rice and 40 DAS and 50 DAS in direct seeded rice. Equal spacing of 20cm x 15cm was adopted in direct seeding and normal transplanting. For transplanting, 25 days old seedlings were used. The soil kept at saturation level throughout crop growth period. For preparation of particle suspension, ZnO-nanoparticulates were suspended in the deionized water directly and dispersed by ultrasonic vibration for 30 min. The aggregation of particles was avoided by stirring the suspensions with magnetic bars.

At harvest, plant samples from each plots were harvested to record the yield-attributing characteristics, such as the number of panicles m^{-2}, panicle length (cm), panicle weight (g), test weight (g), number of filled and unfilled grains $panicle^{-1}$, sterility percentage and grain yield. The data recorded on various parameters of the crop during the course of investigation was statistically analyzed following the analysis of variance for split plot design given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield attributes:

Direct seeded rice (DSR) recorded significantly higher number of panicles m^{-2} (293.50, 275.29 and 284.42 panicles m^{-2}) over normal transplanted rice (259.42, 247.83 and 253.61 panicles m^{-2}) during 2015, 2016 and in pooled mean, respectively (Table 1). The per cent increase in panicles m^{-2} under direct seeded rice was 13.1, 11.1 and 12.2 % over transplantation during both the years and pooled mean, respectively. Higher no. of panicles m^{-2} under DSR is mainly attributed to significantly more number of seedlings $hill^{-1}$ and tillers per unit area in DSR compared to transplanting. The other yield parameters like panicle length, panicle weight and number of spikelets $panicle^{-1}$ were significantly higher under transplanted rice compared to DSR due to intra plant competition occurred in DSR because of more no. of tillers $hill^{-1}$. Differences in 1000-grain weight were not significant between transplanted and direct-seeded rice.

The DSR has more panicles m^{-2}, which was attributed to higher number of tillers per hill and vigorous plant growth than the transplanted rice. The robust plants under DSR could be due to the deeper and vigorous root growth which enabled them to access nutrients from much greater volume of soil. Crop establishment through direct seeding avoids transplanting shock to the seedlings at initial stage unlike normal transplanting where growth disruption occur due to transplantation shock. Direct seeding under puddled condition provides better opportunity for establishment, deeper and vigorous root system, robust plant growth, more leaf area and LAI, more chlorophyll content, higher light harnessing capacity, more number of tillers and panicles per unit area (Peng *et al*., 2006). While reviewing available literature it was found that poor yield under DSR is mainly caused due to poor or uneven plant population (Rickman *et al*., 2001), heavy weed infestation (Kumar *et al*., 2008) and improper water and nutrient management practices (Sudhir Yadav *et al*., 2011). But in present study, DSR is sown through manual hand dibbling at optimum depth under puddled condition which resulted in good germination and uniform plant population at desired spacing which in turn facilitated proper manual weed control.

RDF+ 2 foliar sprays of nano Zn at 1000 ppm (N_5) recorded significantly higher no. of panicles m^{-2} compared to all other nutrient management practices except RDF+ 2 foliar sprays of nano Zn at 1500 ppm (N_6) (Table 1). Being on par with RDF+ 2 foliar sprays of $ZnSO_4.7H_2O$ at 0.5% (N_4) and RDF+ 2 foliar sprays of nano Zn at 1500 ppm (N_6) treatments, RDF+ 2 foliar sprays of nano Zn at 1000 ppm treatment (N_5) recorded significantly more panicle length, panicle weight and test weight compared to other nutrient management practices. Application of Zn stimulated rice growth, enhanced the tiller production which was finally manifested in superior yield attributes. The increase in the number of panicles might be attributed to adequate Zn supply which may have increased the supply of other nutrients and stimulated the overall plant growth (Syed Talib *et al*., 2016). All the yield attributes like no. of panicles m^{-2}, panicle length (cm), panicle weight (g), test weight (g), number of filled grains $panicle^{-1}$ were significantly lowest and sterility percentage was highest under absolute control (N_1) treatment.

Grain and straw yield

The mean grain yield was 4965 kg ha^{-1} in 2015, 4688 kg ha^{-1} in 2016 and 4829 kg ha^{-1} in pooled mean. In spite of the treatment differences, higher grain yield was recorded during *rabi* 2015 than *rabi* 2016 and it may be attributed to congenial weather parameters (rainfall, solar radiation and temperature) and yield attributes during first year (Table 3).

Direct seeded rice recorded significantly higher grain yield (5198, 4886 and 5047 kg ha^{-1}) over normal transplanted rice (4733, 4489 and 4611 kg ha^{-1}) during both the years and in pooled mean, respectively. The per cent grain yield increase in DSR was 9.84, 8.85 and 9.45 % over normal transplanting during 2015, 2016 and their pooled mean, respectively. Higher grain yield under DSR is mainly attributed to significantly more number of panicles per unit area under DSR compared to transplanting. The other yield parameters like panicle length, panicle weight and number of spikelets $panicle^{-1}$ were significantly higher under transplanted rice compared to DSR due to intra plant competition in DSR because of more no. of tillers $hill^{-1}$. But the benefit of this under transplanted rice could have diminished due to significantly more number of panicles m^{-2} under DSR. Differences in 1000-grain weight were not significant between transplanted and direct-seeded rice. These findings indicate the existence of several yield compensation mechanisms enabling rice to respond differently to various microclimatic conditions associated with different methods of crop establishment (Rao *et al*., 2007).

Table 1. Yield attributes of rice as influenced by crop establishment methods and nutrient management practices (*rabi*, 2015 and 2016)

Treatments	Number of panicle m^{-2}			Panicle length (cm)			Panicle weight (g)			Test weight (g)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Crop establishment methods (M)												
M_1- Direct Seeded Rice (DSR)	293.5	275.3	284.4	23.18	22.79	22.99	3.14	3.08	3.11	22.23	22.15	22.19
M_2- Normal Transplanted Rice (NTP)	259.4	247.8	253.6	24.49	24.08	24.29	3.32	3.28	3.30	22.51	22.42	22.46
SEm±	4.10	4.01	4.23	0.27	0.27	0.27	0.04	0.04	0.03	0.26	0.23	0.24
CD (p=0.05)	18.43	18.03	19.06	1.21	1.24	1.23	0.17	0.18	0.15	NS	NS	NS
Nutrient Management practices (N)												
N_1- Absolute control (No fertilizer)	148.4	135.9	142.1	22.03	21.60	21.82	2.74	2.71	2.73	20.35	20.25	20.30
N_2- Control (RDF)	279.5	262.0	270.9	23.15	22.77	22.96	3.15	3.11	3.13	22.21	22.15	22.18
N_3-RDF+ SA of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}	294.8	279.5	287.1	24.01	23.61	23.81	3.29	3.24	3.26	22.50	22.39	22.44
N_4-RDF+ 2 FS of $ZnSO_4.7H_2O$ @ 0.5%	301.5	286.0	293.7	24.16	23.74	23.95	3.35	3.28	3.31	22.89	22.78	22.83
N_5-RDF+ 2 FS of nano ZnO @ 1000 ppm	319.6	305.5	312.6	24.88	24.48	24.68	3.44	3.39	3.41	23.21	23.13	23.17
N_6-RDF+ 2 FS of nano ZnO @ 1500 ppm	315.0	300.5	307.8	24.82	24.42	24.62	3.42	3.36	3.39	23.08	22.99	23.03
SEm±	4.02	4.03	4.30	0.29	0.28	0.29	0.04	0.04	0.04	0.19	0.20	0.19
CD (p=0.05)	11.61	11.64	12.42	0.84	0.81	0.82	0.13	0.12	0.12	0.56	0.59	0.56
Interactions (MxN)												
Nutrient management at same level of crop establishment												
SEm±	5.69	5.70	6.08	0.41	0.39	0.40	0.06	0.06	0.06	0.27	0.29	0.27
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crop establishment at same or different level of nutrient management												
SEm±	6.61	6.57	6.98	0.46	0.45	0.46	0.07	0.07	0.06	0.36	0.35	0.35
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	276.5	261.6	269.0	23.84	23.44	23.64	3.23	3.18	3.20	22.37	22.28	22.33

Treatments	Filled grains panicle^{-1}			Unfilled grains panicle^{-1}			Sterility percentage (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Crop establishment methods (M)									
M_1- Direct Seeded Rice (DSR)	124.66	116.04	120.34	9.68	12.28	10.98	7.37	9.76	8.56
M_2- Normal Transplanted Rice (NTP)	134.36	125.76	130.07	8.81	11.25	10.03	6.30	8.38	7.34
SEm±	1.88	1.70	1.46	0.16	0.17	0.15	0.12	0.16	0.15
CD (p=0.05)	8.47	7.65	6.58	0.73	0.77	0.69	0.56	0.73	0.65
Nutrient Management practices (N)									
N_1- Absolute control (No fertilizer)	109.33	100.79	105.05	18.37	20.88	19.63	14.42	17.23	15.82
N_2- Control (RDF)	125.31	116.66	120.98	10.32	12.85	11.59	7.63	9.95	8.79
N_3-RDF+ SA of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}	131.53	122.89	127.20	8.29	10.80	9.54	5.94	8.11	7.02
N_4-RDF+ 2 FS of $ZnSO_4.7H_2O$ @ 0.5%	132.73	124.09	128.40	7.87	10.38	9.13	5.62	7.75	6.68
N_5-RDF+ 2 FS of nano ZnO @ 1000 ppm	139.75	131.13	135.46	5.46	7.98	6.72	3.77	5.76	4.77
N_6-RDF+ 2 FS of nano ZnO @ 1500 ppm	138.44	129.85	134.14	5.17	7.68	6.42	3.62	5.61	4.62
SEm±	1.45	1.43	1.28	0.20	0.18	0.20	0.15	0.17	0.17
CD (p=0.05)	4.19	4.13	3.71	0.59	0.53	0.57	0.43	0.48	0.50
Interactions (MxN)									
Nutrient management at same level of crop establishment									
SEm±	2.05	2.02	1.82	0.29	0.26	0.28	0.21	0.23	0.25
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crop establishment at same or different level of nutrient management									
SEm±	2.66	2.51	2.21	0.31	0.29	0.30	0.23	0.27	0.27
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	129.51	120.90	125.21	9.25	11.76	10.51	6.83	9.07	7.95

RDF- Recommended Dose of Fertilizers (N, P_2O_5& K_2O @ 120:60:40 kg ha^{-1}); SA- Soil Application; FS- Foliar Spray; NS- Non Significant

Straw yield was also significantly higher under DSR (6675, 6447 and 6561 kg ha^{-1} during 2015, 2016 and pooled mean, respectively) compared to normal transplanting. Increase in straw yield was to the tune of 11.3, 10.9 and 11.1% under DSR over NTP during both the years and pooled mean, respectively (Table 3). This might be due to more number of tiller per unit area and higher dry matter production in DSR. There was no significant difference between direct seeded rice and normal transplanting in respect of harvest index.

RDF+ 2 FS of nano Zn at 1000 ppm (N_5) was found to give significantly higher grain yield during both the years of study over other nutrient management practices except RDF+ 2 FS of nano Zn @ 1500 ppm (N_6) (Table 3). The grain yield of rice in RDF+ 2 FS of nano Zn at 1000 ppm (6070, 5659 and 5878 kg ha^{-1}) and RDF+ 2 FS of nano Zn @ 1500 ppm (5978, 5574 and 5776 kg ha^{-1}) were statistically at par with each other but these nutrient management practices were significantly superior over absolute control (2335, 2274 and 2305 kg ha^{-1}), RDF (4739, 4469 and 4604 kg ha^{-1}), RDF+ SA of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} (5187, 4993 and 5090 kg ha^{-1}) and RDF+ 2 FS of $ZnSO_4.7H_2O$ @ 0.5% (5483, 5157 and 5320 kg ha^{-1}) during 2015, 2016 and pooled mean respectively. The per cent increase in pooled grain yield was 10.54, 15.54, 25.44 and 27.65% in RDF+ SA of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} (N_3), RDF+ 2 FS of $ZnSO_4.7H_2O$ @ 0.5% (N_4), RDF+ 2 FS of nano Zn @ 1500 ppm (N_6) and RDF+ 2 FS of nano Zn @ 1000 ppm (N_5) compared to RDF application (N_2), respectively.

Significantly lowest grain yield (2335, 2274 and 2305 kg ha^{-1} in 2015, 2016 and pooled mean, respectively) was recorded under absolute control (N_1). Application of recommended dose of fertilizer NPK (N_2) to the rice resulted in 102.95, 92.82 and 99.77% grain yield increase during 2015, 2016 and pooled mean respectively over absolute control treatment (no fertilizer). RDF along with soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} (N_3) recorded significantly higher grain yield (5187, 4993 and 5090 kg ha^{-1} in 2015, 2016 and pooled mean, respectively) compared to only RDF application (4739, 4469 and 4604 kg ha^{-1} in 2015, 2016 and pooled mean, respectively). Soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} (N_3) increase grain yield in the tune of 9.44, 11.71 and 10.54% during 2015, 2016 and pooled mean respectively over NPK RDF application (N_2). Two foliar application of $ZnSO_4.7H_2O$ @ 0.5% (N_4) was found better over soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} (N_3) and resulted in 5.71, 3.29 and 4.52% grain yield increase during 2015, 2016 and pooled mean, respectively over soil application of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}.

Significant increase in grain yield due to nano zinc application is mainly attributed to significantly higher number of panicle m^{-2}, panicle length, panicle weight, test weight, number of spikelets per panicle.

The increased yield attributes might be due to role of Zn in biosynthesis of Indole acetic acid (IAA) and especially due to its role in initiation of primordial reproductive parts and partitioning of photosynthates towards them. It is evident that application of Zn stimulated rice growth, enhanced the tiller production which was finally manifested in superior yield attributes. The increase in the number of panicles m^{-2} might be attributed to adequate Zn supply which may have increased the supply of other nutrients and stimulated the overall plant growth. The increase in the number of grains $panicle^{-1}$ might have been owing to its enhancing effect on the physiological activities, photosynthesis and translocation and assimilation of photosynthates and formation of higher number of spikelets during the spikelet initiation process which ultimately resulted in higher number of grains/panicle (Syed Talib *et al.*, 2016).

Significantly higher straw yield was recorded in RDF+ 2 FS of nano Zn at 1000 ppm (N_5) (7570, 7224 and 7397 kg ha^{-1} during 2015, 2016 and pooled mean, respectively) compared to other nutrient management practices except RDF+ 2 FS of nano Zn at 1500 ppm (N_6). In respect to harvest index, there was no significant difference between nutrient management practices except absolute control (N_1). Significantly lowest harvest index (41.67, 40.84 and 41.25% during both the year and pooled mean) was recorded in absolute control (N_1).

CONCLUSION

The study revealed that direct seeding through hand dibbling under puddled condition could be an option for rice cultivation as normal transplanting

Table 2. Yield and harvest index of rice as influenced by crop establishment methods and nutrient management practices (*rabi*, 2015 and 2016)

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index(%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Crop establishment methods (M)									
M_1- Direct Seeded Rice (DSR)	5198	4886	5047	6675	6447	6561	43.58	42.82	43.20
M_2- Normal Transplanted Rice (NTP)	4733	4489	4611	6000	5813	5907	43.81	43.43	43.62
SEm±	98	83	89	121	109	101	0.52	0.61	0.49
CD (p=0.05)	441	373	401	545	492	455	NS	NS	NS
Nutrient Management practices (N)									
N_1- Absolute control (No fertilizer)	2335	2274	2305	3270	3320	3295	41.67	40.84	41.25
N_2- Control (RDF)	4739	4469	4604	6154	5981	6068	43.47	42.77	43.12
N_3-RDF+ SA of $ZnSO_4.7H_2O$ @ 25 kg ha^{-1}	5187	4993	5090	6593	6462	6527	44.02	43.63	43.83
N_4-RDF+ 2 FS of $ZnSO_4.7H_2O$ @ 0.5%	5483	5157	5320	6902	6656	6779	44.25	43.66	43.96
N_5-RDF+ 2 FS of nano ZnO @ 1000 ppm	6070	5659	5878	7570	7224	7397	44.54	43.96	44.25
N_6-RDF+ 2 FS of nano ZnO @ 1500 ppm	5978	5574	5776	7537	7137	7337	44.21	43.89	44.05
SEm±	134	109	111	147	114	121	0.40	0.55	0.51
CD (p=0.05)	386	315	320	424	328	349	1.15	1.58	1.47
Interactions (MxN)									
Nutrient management at same level of crop establishment									
SEm±	189	154	157	208	161	171	0.56	0.77	0.72
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crop establishment at same or different level of nutrient management									
SEm±	198	163	168	225	183	186	0.73	0.94	0.82
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	4965	4688	4829	6337	6130	6234	43.70	43.13	43.41
Coefficient of Variation (%)	9.7	8.7	9.0	9.4	8.7	7.9	5.9	7.0	5.5

RDF- Recommended Dose of Fertilizers (N, P_2O_5& K_2O @ 120:60:40 kg ha^{-1}); SA- Soil Application; FS- Foliar Spray; NS- Non Significant required more labour and delayed maturity compared to direct seeding. Application of RDF + nano ZnO foliar application is new innovation to overcome Zn deficiency in rice and enhancing grain yield over $ZnSO_4.7H_2O$ application.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON YIELD ATTRIBUTES AND YIELD OF BABY CORN IN BABY CORN (*Zea mays*. L) - HYACINTH BEAN (*Lablab purpureus* var *typicus*) CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted at Horticultural Research Station, Adilabad during *kharif*, 2015 and 2016 and *rabi* seasons of 2015-16 and 2016-17 to study the effect of integrated nutrient management practices on yield attributes and yield of baby corn in baby corn-hyacinth bean cropping system. The experiment was laid out in a randomized block design for baby corn during *kharif*, 2015 season with seven treatments comprised of T1: 25% N through FYM + 75% RDF (Recommended dose of fertilizer), T2: 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T3: 25% N through vermicompost + 75% RDF, T4: 25% N through vermicompost + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T5: 100% RDF, T6: 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T7: Control (No fertilizer application) replicated thrice. Each main treatment is sub divided into four sub plots and the treatments S1-100% RDF, S2-75% RDF, S3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (seed treatment) and S4-75% RDF + *Bradyrhizobium* @ 500 g ha^{1} (seed treatment), were imposed for hyacinth bean in *rabi* season and data of *kharif,* 2016 was analyzed in split plot design. All the treatments (organic, inorganic sources of nutrition in conjunction with bio-fertilizers) showed significantly higher number of cobs $plant^{-1}$, cob length, cob girth, cob width, cob weight with or without husk and yield over un-fertilized control. Among the different treatments, application of 75% RDF integrated with 25% RDN through vermicompost in conjunction with bio-fertilizers recorded significantly higher number of cobs plant $^{-1}$ (2.23 and 2.22), cob length (12.50 and 12.24 cm), cob girth (5.74 and 5.65 cm), cob width (1.86 and 1.83 cm), cob weight without husk (13.46 and 12.06 g), cob yield with husk (12290 and 11727 kg ha^{-1}), cob yield without husk (2049 and 1890 kg ha^{-1}) and stover yield (24020 and 21165 kg ha^{-1}) during *kharif*, 2015 and 2016, respectively. Application of 100% RDF along with seed treatment with *Bradyrhizobium* to hyacinth bean crop during *rabi* 2015-16 resulted in significantly higher baby cob weight without husk (9.95 g) in succeeding *kharif*, 2016 over 100% RDF, 75% RDF and 75% RDF + seed treatment with *Bradyrhizobium*.

Maize (*Zea mays* L) is the third most important cereal crop next to rice and wheat and has the highest production potential among the cereals. For diversification and value addition of maize as well as growth of food processing industries, recent development is growing maize for vegetable purpose, which is commonly known as 'baby corn'. Baby corn is de-husked ear, harvested two or three days after silk emergence. Baby corn has high nutrient content, a good source of foliate, vitamin B6, riboflavin, vitamin A, C, rich in potassium, phosphorus and fiber content and low in fat content, free from saturated fat and cholesterol, very low in sodium. It has nutritive value similar to that of non-legume vegetable such as cauliflower, tomato, cucumber and cabbage (Paroda and Sashi, 1994). Cultivation of baby corn to diversify cropping pattern and to increase productivity of the cropping systems has been considered important for improving the livelihood and income of resource poor farmers in South Asia. Baby corn is a profitable crop that allows a diversification of production, aggregation of value, and increased income. Being a very short duration crop, it can be grown throughout the year and it also fits well in intensive cropping systems. Use of organic manures along with inorganic fertilizers to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture. Since organic manures improve the soil physical, chemical and biological properties along with conserving soil moisture. Cultivation of baby corn by integrated nutrient management (INM) approach might be the most feasible way to get the best quality produce for competitive international markets.

Lablab bean or hyacinth bean is one of the most ancient among the cultivated legumes and is grown throughout the tropical regions of Asia, Africa and America. The crop is indigenous to India and grown all over the country. The crop is put to multipurpose uses such as pulse, vegetable, fodder. The crop is mainly grown for green pods, while the dry seeds are used in the preparation of various vegetarian dishes and is rich in protein. The foliage of the crop provides silage and green manure. The dwarf, bushy types are determinate and are photo insensitive and

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can be cultivated throughout the year. Dwarf varieties (determinate bush type) have a potential for more extensive cultivation of the crop, because the plants require no support system, the pods mature uniformly and the crop is amenable to mechanical harvesting which will reduce cost and labour.

Erratic behavior of rainfall pattern, especially the late onset of monsoon, early cessation of rainfall, long duration cultivars are failing to yield good returns in Telangana region. Application of heavy doses of chemical fertilizers without organic manures is causing deterioration of soil health in terms of physical and chemical properties of soil, declining soil microbial activities, reduction in soil humus, increased pollution of soil, water and air.

In view of the above baby corn of 55-60 days duration is selected for testing during *kharif* and 130-140 days duration cultivar hyacinth bean a legume crop for *rabi*. The entire cropping system will be completed in around 185-200 days, premium price is there in the market for baby corn and not much fluctuation in the price of hyacinth bean round the year and hence the system can be a profitable system. Though maize is an exhaustive crop, baby corn is a short duration crop and hyacinth bean is a legume and the use of organic manures and microbial cultures as part of integrated nutrient management will sustain soil health. Hence, a study was initiated to know the effect of integrated nutrient management practices on yield attributes and yield of baby corn, in baby corn-hyacinth bean cropping system and to evaluate the efficacy of FYM and vermicompost in conjunction with microbial culture and inorganic fertilizers.

MATERIALS AND METHODS

The experiment was conducted at Horticultural Research Station farm, Adilabad during *kharif,* 2015 and 2016. The experimental site is at an altitude of 264 m above mean sea level on 79° 56’ 03" E longitude and 19°08’ 09" N latitude. The experimental soil was sandy clay loam in texture, neutral in reaction, medium in available nitrogen, phosphorous and potassium. The soil belongs to the order Alfisol of shallow to medium depth. The experiment was laid out in a randomized block design for baby corn during *kharif*, 2015 season with seven treatments comprised of T1: 25% N through FYM + 75% RDF (Recommended dose of fertilizer), T2: 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T3: 25% N through vermicompost + 75% RDF, T4: 25% N through vermicompost + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T5: 100% RDF, T6: 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each, T7: Control (No fertilizer application) replicated thrice. Each main treatment is sub divided into four sub plots and the treatments S1-100% RDF, S2-75% RDF, S3-100% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (seed treatment) and S4-75% RDF + *Bradyrhizobium* @ 500 g ha^{1} (seed treatment), were imposed for hyacinth bean in *rabi* season and data of *kharif,* 2016 was analyzed in split plot design.

Manures (FYM or vermicompost) and fertilizers (urea, SSP and muriate of potash) were applied as per the treatment. Manures were incorporated into the soil before sowing. Nitrogen was applied in three splits in the form of urea at 10, 25 and 40 DAS. Entire P_2O_5 and K_2O was applied as basal through single super phosphate and muriate of potash. *Azospirillum* (nitrogen fixing bacterial formulation) and *Bacillus megaterium* (phosphorus solubilizing bacterial formulation) @ 5 kg ha^{-1} each was applied to soil after incubation with 50 kg FYM for baby corn as per the treatments. G-5414 variety of baby corn which grows to height of 180-200 cm and matures within 50-55 days was selected for testing. The crop was sown on 22nd and 3rd July in 2015 and 2016, respectively. Two seeds were dibbled $hill^{-1}$ at a depth of 3-4 cm with a spacing of 60 cm x 15 cm. Gap filling was done on 7th day after sowing and thinning was done on 14th day after sowing. Atrazine @1.0 kg a.i ha^{-1} was applied two days after sowing to control the weeds. The field was maintained weed free condition by hand weeding at 15 and 30 DAS. Biometric observations on baby corn were recorded at harvest. Five plants were selected at random and ear marked in the net plot area in each treatment for recording the observations on yield components (cob length, cob girth, number of cobs $plant^{-1}$ and cob weight) and yield.

The data on observations were analyzed statistically by applying the technique of analysis of variance as outlined by Panse and Sukhatme (1978) for Randomized Block Design and for Split plot design as suggested by Gomez and Gomez (1984). Statistical significance was tested by F test. Critical difference for treatment means was evaluated at 5 per cent level of probability (P=0.05).

RESULTS AND DISCUSSION

Yield attributes

Number of cobs plant^{-1}:

Organic and inorganic sources of nutrition with or without use of bio fertilizers to baby corn showed significantly higher number of cobs plant^{-1} during both the years of study 2015 & 2016 over un-fertilized control. Cob number plant^{-1} ranged from 0.95 to 2.23 in 2015 and 1.47 to 2.22 during 2016 in different treatments. Integration of 75% RDF with 25% N through vermicompost along with the use of bio fertilizers (*Azospirillum* and *Bacillus megaterium*) showed significantly higher number of cobs plant^{-1} compared to rest of the treatments of 75% RDF with or without bio-fertilizers integrated with 25% N through FYM or vermicompost and un-fertilized control. Significantly lower cob number plant^{-1}was recorded with un-fertilized control than rest of the treatments during both the years of study (Table 1). Aravinth *et al.,*(2011) reported that use of vermicompost in addition to inorganic sources of nutrition resulted in higher cobs plant^{-1}. Similar results of higher cobs plant^{-1} were also noticed by Lone *et al.,* (2013) in baby corn by the use of FYM.

Integration of 75% RDF with 25% RDN through FYM to baby corn showed significantly higher number of cobs plant^{-1} over unfertilized control and was at par with 100% RDF during both the years of study, though these were significantly lower than other organic combination treatments. Use of bio-fertilizer along with 75% RDF with 25% RDN through FYM was at par with 100% RDF in conjunction with the use of bio-fertilizers, 75% RDF integrated with 25% RDN through vermicompost and significantly higher number of cobs plant^{-1} than rest of the treatment except vermicompost with bio-fertilizers in both the years.

Residual effect of 100% RDF application along with seed treatment with *Bradyrhizobium* to hyacinth bean during *rabi*, 2015-16 resulted in significantly higher number of baby cobs plant^{-1} in the succeeding *kharif* season over 75% RDF with or without use of *Bradyrhizobium* seed treatment and was at par with 100% RDF application.

Cob length, girth and width (cm):

Organic (FYM and vermicompost) and inorganic sources of nutrition (75% RDF and 100% RDF with chemical fertilizers) with or without use of bio fertilizers have showed significantly higher cob length, girth and width over un-fertilized control (Table 1). Different treatments brought out significant variation in cob length, girth, and width and the cob length, girth and width varied from (7.50 to 12.50 cm and 7.11 to 12.24 cm), (3.98 to 5.74 cm and 3.73 to 5.65 cm) and (1.27 to 1.86 cm and 1.27 to 1.83 cm) during 2015 and 2016 respectively. Roy *et al.,* (2015) reported significant higher cob length with application of 75%RDF + FYM than 75% RDF and 100%RDF alone.

Conjunctive use of inorganic fertilizers *i.e.,* 75% RDF with 25% N through vermicompost along with bio-fertilizer (*Azospirillum* and *Bacillus megaterium*) resulted in significantly higher cob length, girth and width during both the years of study than all the other treatments. Significantly lower cob length, girth and width were recorded with un-fertilized control than rest of the treatments.

Integration of 75% RDF with 25% N through vermicompost showed significantly higher cob length, girth and width over un fertilized control and was at par with 100% RDF, 100% RDF along with the use of bio-fertilizers and 75% RDF + 25% N through FYM in conjunction with or without the use of bio fertilizers.

Higher cob length was reported by Aravinth *et al.,* (2011) with use of vermicompost along with RDF in baby corn. Similar results of increased cob girth were noticed by Ravinchandran *et al.,*2016, Singh *et al.,* (2014) with integration of organic manure (FYM) along with inorganic fertilizers, Jinjala *et al.,* (2016) with integration of inorganic sources of nutrition in conjunction with bio-fertilizers.

Application of 75% and 100% RDF with or without seed inoculation of *Bradyrhizobium* to hyacinth bean during *rabi* 2015-16 did not show any significant residual effect on cob length, girth and width of baby corn in the succeeding *kharif,* 2016 season.

Cob weight with or without husk (g):

Application of 25% N through organic manures (FYM or vermicompost) integrated with 75% RDF along with or without the use of bio-fertilizers (*Azospirillum* and *Bacillus megaterium*) and 100% RDF with or without the use of bio-fertilizers, showed significantly higher cob weight with and without husk during both the years of study and significantly higher cob weight was with integration of 75% RDF with 25% RDN

Table-1. Effect of integrated nutrient management practices on yield attributes of baby corn during *kharif*, 2015 and 2016

Treatment given to *kharif* baby corn	2015						2016					
	Cobs plant^{-1}	Cob length (cm)	Cob girth (cm)	Cob width (cm)	Cob weight (g)		Cobs plant^{-1}	Cob length (cm)	Cob girth (cm)	Cob width (cm	Cob weight (g)	
					With husk	Without husk					With husk	Without husk
T_1- 25% N through FYM + 75% RDF	1.78	10.69	5.25	1.68	46.80	9.26	1.83	9.31	5.13	1.63	42.68	9.03
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	2.00	10.83	5.60	1.72	47.33	10.00	1.98	9.64	5.54	1.68	43.16	9.08
T_3- 25% N through Vermicompost + 75% RDF	2.02	10.95	5.58	1.76	49.17	10.00	2.02	9.65	5.46	1.71	43.68	9.26
T_4- T4: 25% N through Vermicompost + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	2.23	12.50	5.74	1.86	55.59	13.46	2.22	12.24	5.65	1.83	48.73	12.06
T_5- 100% RDF	1.75	10.66	5.24	1.71	46.29	9.20	1.78	9.89	5.12	1.61	42.36	9.01
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	2.00	10.96	5.55	1.80	49.86	10.38	1.98	9.90	5.44	1.74	43.10	9.36
T_7- Control (No fertilizer application)	0.95	7.50	3.98	1.27	15.88	3.58	1.47	7.11	3.73	1.27	23.99	5.13
S.Em±	0.06	0.41	0.15	0.05	1.55	0.40	0.06	0.50	0.15	0.05	0.97	0.13
C.D. (P=0.05)	0.20	1.27	0.45	0.16	4.77	1.23	0.18	1.53	0.47	0.16	3.00	0.41
Treatment given to *rabi* crop (hyacinth bean)												
S_1- 100% RDF							1.91	9.87	5.20	1.61	42.49	9.25
S_2- 75% RDF							1.80	9.33	5.01	1.67	37.37	8.25
S_3 100% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (Seed treatment)							2.00	9.90	5.33	1.60	44.57	9.95
S_4- 75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (Seed treatment)							1.88	9.60	5.07	1.66	39.98	8.50
S.Em±							0.03	0.24	0.17	0.05	0.86	0.19
C.D. (P=0.05)							0.10	NS	NS	NS	2.46	0.54
Interaction												
Bean treatment means at same level of baby corn INM treatments												
S.Em±							0.09	0.64	0.44	0.14	2.28	0.50
C.D. (P=0.05)							NS	NS	NS	NS	NS	NS
INM treatment means of baby corn at same level of bean treatments												
S.Em±							0.10	0.74	0.41	0.13	2.20	0.45
C.D. (P=0.05)							NS	NS	NS	NS	NS	NS

through vermicompost in conjunction with bio-fertilizers (55.59 g & 48.73 g and 13.46 g & 12.06 g) with or without husk respectively and significantly lower (15.88 g and 23.99 g respectively) was with unfertilized control during both the years of study *kharif*, 2015 and 2016 than rest of treatments.

Residual effect with application of 100% RDF (chemical fertilizers) along with seed treatment with *Bradyrhizobium* to hyacinth bean crop during *rabi,* 2015-16 resulted in significantly higher baby cob weight with or without husk in succeeding baby corn crop over 75% RDF with or without seed treatment with *Bradyrhizobium* and was at par with 100% RDF.

Superior vegetative growth (plant height, leaf area index, dry matter production) due to integrated effect of organic manures along with inorganic fertilizer and bio-fertilizers has realized in the increased baby cob weight with or without husk. Ashoka *et al.,*(2009) reported similar results with integration of RDF with vermicompost and Edwin Lukham *et al.,* (2003) with integration of RDF with FYM.

Significant improvement in yield attributes by integrated nutrient management practices in baby corn may be attributed to the combined effect of organic and inorganic sources which helped in maintain higher auxin level resulting in better plant height, LAI presumably chlorophyll content of the leaves resulted in better interception, absorption and utilization of radiant energy leading to higher photosynthesis rate and finally more accumulation of dry matter by the plants. The overall improvement of crop growth reflected into better source and sink relationship, which in turn enhanced the yield attributes as found by Ashoka *et al* (2009).

Cob Yield (kg ha^{-1}):

In *kharif*, 2015 and 2016 cob yield with husk ranged from 4279 to 12290 kg ha^{-1} and 4393 to 11727 kg ha^{-1} respectively. Similarly cob yield without husk was 823 to 2049 kg ha^{-1} and 749 to 1890 kg ha^{-1} respectively. Integration of 75% RDF with 25% RDN through vermicompost in conjunction with the use of bio-fertilizers (*Azospirillum* and *Bacillus megaterium*) showed significantly higher cob yields with or without husk during both the years of study (*kharif,*2015 and 2016) over integration of 75% RDF + 25% N through vermicompost, integration of 75% RDF + 25% N through FYM with and without the use of bio-fertilizer, 100% RDF, 100% RDF + bio fertilizer and un-fertilized control (Table 2). Significantly lower yield (cob with or without husk) was recorded with un-fertilized control than rest of the treatments.

Ashish Shivran *et al.* (2015) reported similar results with application of N through chemical fertilizer and vermicompost in 75:25 proportions over 100% sole N chemical fertilizer application and 50:50 (chemical fertilizer and vermicompost). Similar results were also recorded by Aravinth *et al.*, 2011; Ashoka *et al.,* 2008, Dadarwal *et al.,* 2009 and Prasanna Kumar *et al.,* 2007.

Integration of 75% RDF with 25% N through FYM showed on par cob yields with or without husk with 100% RDF (chemical fertilizer) and significantly superior to unfertilized control and significantly lower than rest of the treatments during *kharif*, 2015 and 2016.

Integration of 75% RDF with 25% N through FYM in conjugation with the use of bio-fertilizers, integration of 75% RDF with 25% N through vermicompost and 100% RDF along with bio-fertilizers showed on par yields of baby corn during both the years of study (*kharif,* 2015 and 2016) and were significantly superior to 100% RDF alone, integration of 75% RDF with 25% N through FYM and unfertilized control.

Application of 100% RDF with or without seed treatment with *Bradyrhizobium* to hyacinth bean during *rabi* crop resulted in significantly higher cob yield with or without husk in succeeding *kharif* baby corn crop over 75% RDF alone or with *Bradyrhizobium* seed treatment.

Stover yield (kg ha^{-1}):

Stover yield ranged from 13821 to 24020 kg ha^{-1} in 2015 and 12168 to 21165 kg ha^{-1} during second year (Table-2). Application of 75% RDF along with 25% N through vermicompost in conjunction with bio-fertilizers (*Azospirillum and Bacillus megaterium*) resulted in significantly higher stover yield of baby corn over rest of the treatments during both the years of study (*kharif* 2015 and 2016). Significantly lower stover yield was with control over rest of the treatments in both the years. Integration of 75% RDF with 25% N through FYM resulted in significantly higher stover yields over un-fertilized control and was at par with 100% RDF with or without the use of bio-fertilizer during the year 2015 and significantly lower than rest of the treatments except control in 2016. Integration of 75%

Table-2.Effect of integrated nutrient management practices on cob yield (kg ha^{-1}) with and without husk and stover yield of baby corn during *kharif*, 2015 and 2016

Treatment given to *kharif* baby corn	2015			2016		
	Cob yield (kg ha^{-1})		Stover yield(kg ha^{-1})	Cob yield (kg ha^{-1})		Stover yield (kg ha^{-1})
	With husk	Without husk		With husk	Without husk	
T_1- 25% N through FYM + 75% RDF	8204	1602	19344	8147	1495	18919
T_2- 25% N through FYM + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	9032	1803	20865	8882	1596	19708
T_3- 25% N through Vermicompost + 75% RDF	9400	1801	21475	8994	1601	19762
T_4- T4: 25% N through Vermicompost + 75% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	12290	2049	24020	11727	1890	21165
T_5- 100% RDF	8049	1542	19060	8199	1471	19364
T_6- 100% RDF + *Azospirillum* and *Bacillus megaterium* @ 5 kg ha^{-1} each	9344	1807	20398	8824	1553	19631
T_7- Control (No fertilizer application)	4279	823	13821	4393	749	12168
S.Em$\pm$	267	64	429	200	16	385
C.D. (P=0.05)	824	198	1321	617	49	1187
Treatment given to *rabi* crop (hyacinth bean)						
S_1- 100% RDF				8824	1546	19086
S_2- 75% RDF				7880	1369	17833
S_3- 100% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (Seed treatment)				9073	1590	19410
S_4- 75% RDF + *Bradyrhizobium* @ 500 g ha^{-1} (Seed treatment)				8033	1411	18365
S.Em$\pm$				202	16	280
C.D. (P=0.05)				577	45	798
Interaction						
Bean treatment means at same level of baby corn INM treatments						
S.Em$\pm$				535	41	740
C.D. (P=0.05)				NS	NS	NS
INM treatment means of baby corn at same level of bean treatments						
S.Em$\pm$				504	39	748
C.D. (P=0.05)				NS	NS	NS

RDF with 25% N through vermicompost was on par with integration of 75% RDF with 25% N through FYM and 100% RDF in conjunction with the use of bio-fertilizers.

During 2016, integration of 75% RDF with 25% RDN through vermicompost, integration of 75% RDF with 25% N through FYM in conjugation with or without the use of bio-fertilizers and 100% RDF with or without the use of bio-fertilizers showed on par stover yields and were significantly superior to un-fertilized control. Significantly higher stover yields was recorded due to residual effect of 100% RDF applied with or without *Bradyrhizobium* seed treatment to hyacinth bean crop during *rabi* 2015-16 in the succeeding *kharif* 2016 over 75% RDF with or without seed treatment with *Bradyrhizobium* to hyacinth bean.

Organic manures along with inorganic fertilizers and seed inoculation with *Azospirillum* and *Bacillus megaterium* had pronounced effect on green cob yield and stover yield, these might be due to fixation of atmospheric nitrogen and secretion of growth promoting substances of *Azospirillum* and increased bacterial efficiency by phospho-bacteria combined together might have increased growth and yield parameters as reported by Somani *et al.,*(2005). Similar effect of increased cob yields was also observed by Thavaprakash *et al.,* 2005 in baby corn due to synergistic effect of INM, Thavaprakash and Velayudham (2007) in sweet corn and Nath *et al*., (2009).

Integrated use of fertilizers did bring about significant improvement in overall growth of crop by providing need based nutrients from initial stage and increasing supply of N, P and K in more synchronized way with the treatment receiving integrated supply of nutrients from organic manures, inorganic and bio-fertilizers which expressed in terms of cob plant^{-1}, cob length, cob girth, cob weight with or without husk by virtue of increased photosynthetic efficiency.

Greater availability of photo-synthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased number of cobs plant^{-1}, cob girth, cob length, cob weight and yield with INM treatments.

CONCLUSION

Based on the above results it can be concluded that higher cob yield with or without husk and stover yield can be realized with combined use of 75% RDF with 25% N through vermicompost in-conjunction with bio-fertilizers followed by 100% RDF with bio-fertilizers, integration of 25% N through vermicompost and 75% RDF and combined use of 25% N through FYM with 75% RDF in-conjunction with bio-fertilizers for *kharif* baby corn on Alfisols under Northern Telangana Zone.

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Research Article
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DETERMINANTS OF KEY ENTREPRENEURIAL CHARACTERISTICS - A STUDY OF ENTREPRENEURIAL ATTITUDE OF AGRICULTURAL STUDENTS OF TELANGANA STATE

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ABSTRACT

The present study was carried out to study the Profile characteristics of Agricultural Students of Telangana State, to study the agreement among several rankers with respect to the characteristics-Risk Orientation , Achievement Orientation, Innovativeness, Market Orientation, Decision making ability, to identify the key Entrepreneurial characteristics. The study concluded that about 65.5% of the agricultural students were from the age group of 19-24 years, 40.8% were first born child,54% had first class marks & 23% had distinction, with low participation in extracurricular activities, 88.3 % of their fathers were literates and were engaged in government service and business, and 45.8 % of them are having 2.6 to 5 acres of land.Factor Analysis was done for extracting the key Entrepreneurial characteristics and Kendall's Co-efficient of Concordance was used to test the agreement among several rankers. The result showed that there is strong agreement among the respondents with respect to ranking each of the attributes under Risk Orientation as Kendall's W = 0.59 & moderate agreement with respect to ranking the attributes under Market Orientation with W= 0.292. There is no agreement among the respondents with respect to ranking each of the attributes under Achievement Orientation, Innovativeness, and Decision making ability since Kendall's w is equal to 0.113, 0.182, and 0.064 respectively.Three key factors were extracted;finally ranking of the indicators has been made on the basis of factor scores. Further from the Kendall's Co-efficient value it is concluded there is complete disagreement between the raters regarding each of the following - Agro based enterprise as the best option to earn money for landless rural people, Agro based enterprise can be a good source of income for low investors and establishment of Agro based enterprise is unproductive.

The entrepreneurship is a very old concept according to which anyone who runs business is called an entrepreneur. The more precise meaning of entrepreneur is; one who perceives a need and then brings together manpower, material and capital required to meet that need. Entrepreneur is one who understands the market dynamics and searches for change respond to it and exploit it as an opportunity a person who organizes and manages any enterprise, especially a business, usually with considerable initiative and risk.

Agriculture sector plays a formidable role in the sustainable growth and development of Indian economy. It provides for the food and nutrition requirements of 1.3 billion Indian people and creates employment opportunities through forward and backward linkages to support 60% of Indian population.

While it has achieved substantial progress over the years regarding food security, accessibility and affordability, the agriculture sector is still challenged by low productivity, low profitability, increase in input costs, wastage of crops due to lack of storage and supply chain management. These challenges present a host of opportunities for Agri-entrepreneurs.

Agri-entrepreneurship employs entrepreneurial skills, models and innovative ideas to economically solve problems in the agriculture sector and increase the profitability of the farming business.

Agri-entrepreneurship can play a significant role in solving the challenges related to information dissemination, farm management, capital availability, mechanization of farm and the agriculture supply chain.

As opposed to the increasing demand for higher education, unemployment of university graduates has been rapidly increasing. Even though accurate data on unemployment is not available, it is believed that over 28 per cent of agricultural college graduates need to find job (Jalali 2003). This is why many universities offer entrepreneurial courses, activities and stimulate students to involve in entrepreneurial activities. Universities are playing an important role in entrepreneurship development (Menzies, 2000). But the point is that, could

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entrepreneurship be made in universities? and could entrepreneurship be learned?

Agricultural students are now better informed about professional opportunities than in the past. The employment opportunities, the type of jobs and the earning potential influence student as well as their parents to decide on the preferred course. With the advent of internet, freedom and mobility for student, they are making their choice in rapidly changing global economy.

The right choice of discipline and attitude towards the education imparted through the institute and vocational decisions have to occupy a central place in the life of the student community.

The objectives of this study are delineated below.

1. To study the Profile characteristics of Agricultural Students of Telangana State.
2. To study the agreement among several rankers with respect to the characteristics-Risk Orientation, Achievement Orientation, Innovativeness, Market Orientation, Decision making ability
3. To identify the key Entrepreneurial characteristics.

MATERIALS AND METHODS

The data was collected using a questionnaire which was distributed randomly to 120 students of Agriculture belonging to various Agricultural Colleges of Telangana State.The questionnaire was administrated to a seven points Likert type summated rating scales of questionnaire from strongly disagree (-3) to strongly agree (+3) were adopted to identify the characteristics.

SPSS was used to perform statistical analysis of the data collected through questionnaires. with an aim to study the Profile characteristics of Agricultural Students of Telangana State, to study the agreement among several rankers with respect to the characteristics-Risk Orientation, Achievement Orientation, Innovativeness, Market Orientation, Decision making ability and to identify the key entrepreneurial characteristics.

The independent variables undertaken in this study are viz. age, birth order, academic achievement, participation in extra-curricular activities, father's education, father's occupation, family land holding, risk orientation, achievement motivation, innovativeness, market orientation and decision making ability were measured with the help of suitable scale and procedures.

The dependent variables like attitude towards agricultural entrepreneurship was measured with the help of scale developed by Meenaben Patel (2009) with due modification. The methods used were Descriptive statistics, Factor analysis and Kendall's test a Non-parametric technique.

Tools of Data Analysis

The present study has used sophisticated methods of statistics –

1. KENDALL'S COEFFICIENT OF CONCORDANCE

The concept of association between more than two sets of ranking is measured non-parametrically by a statistic known as Kendall's coefficient of concordance. This coefficient is used to express the intensity of agreement among several rankings and is given by

$$W = \frac{12\sum_i R_i^2 - 3K^2 N(N+1)^2}{K^2 N(N^2-1)}$$

Where R_i is sum of all ranks received by option i,

K= No. of sets ranking i.e, no. of rankers and

N= No. of options being ranked.

Kendall's *W* ranges from 0 (no agreement) to 1 (complete agreement).

If the test statistic *W* is 1, then all the survey respondents have been unanimous, and each respondent has assigned the same order to the list of concerns. If *W* is 0, then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of *W* indicate a greater or lesser degree of unanimity among the various responses.

2. FACTOR ANALYSIS

Data was analysed using Varimax rotation. In order to obtain interpretable characteristics and simple structure solutions, researchers have subjected the initial factor matrices to Varimax rotationprocedures (Kaiser, 1958). Varimax rotated factors matrix provides orthogonal common factors. Finally ranking of the indicators has been made on the basis of factor scores.

RESULTS AND DISCUSSION

Frequencies and percentages of various independent variables viz. age, birth order, academic achievement, participation in extra-curricular activities, father's education, father's occupation, family land holding were calculated and found that about 65.5% of the agricultural students were from age group of 19-24 years, 40.8% were first born child,54% had first class marks & 23% had distinction, found with low participation in extracurricular activities, 88.3 % of their fathers were literates and were engaged in government service and business, and 45.8 % of them are having 2.6 to 5 acres of land.

Kendall's test was used to test the agreement of different rankers or respondents with respect to each of the attributes under Risk Orientation, Achievement Orientation, Innovativeness, Market Orientation and Decision making ability. The result showed that there is strong agreement among the respondents with respect to ranking each of the attributes under Risk Orientation as Kendall's W = 0.59 & moderate agreement with respect to ranking the attributes under Market Orientation with W= 0.292. There is no agreement among the respondents with respect to ranking each of the attributes under Achievement Orientation, Innovativeness and Decision making ability since Kendall's W is equal to 0.113, 0.182, and 0.064 respectively.

Reliability and Validity

The reliability value of our surveyed data was 0.6 for the characteristics as given in Table 1. If we compare our reliability value with the standard value alpha of 0.7 advocated by Cronbach (1951), a more accurate recommendation (Nunnally& Bernstein's, 1994) or with the standard value of 0.6 as recommendated by Bagozzi& Yi's (1988) we find that the scales used by us are sufficiently reliable for data analysis. Regarding validity, Kasier – Meyer –Olkin (KMO) measure of Sampling Adequacy is a measure of whether or not the distribution of value is adequate for conducting FA. As per KMO measure, a measure of >0.9 is marvellous, >0.8 is meritorious, >0.7 is middling, >0.6 is mediocre, >0.5 is miserable and <0.5 is unacceptable.

Table 1. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Adequacy	Measure of Sampling	0.600
Bartlett's Test of Sphericity	Approx. Chi-Square	125.523
	df	36
	Sig.	0.000

The data returned a value sampling adequacy of 0.600 indicating middling as presented in Table 1. Bartlett's test of Sphericity is a measure of the

Table 2. Total Variance Explained

Com ponent	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul ative %
1	1.965	21.839	21.839	1.965	21.839	21.839	1.894	21.044	21.044
2	1.806	20.070	41.909	1.806	20.070	41.909	1.520	16.887	37.932
3	1.086	12.064	53.973	1.086	12.064	53.973	1.444	16.042	53.973
4	.927	10.301	64.274						
5	.887	9.860	74.134						
6	.738	8.199	82.333						
7	.630	6.996	89.329						
8	.529	5.878	95.207						
9	.431	4.793	100.000						

Extraction Method: Principal component Analysis.

multivariate normality of the set of distributions. It also tests whether the correlation matrix conducted within the FA is an identity matrix. FA would be meaningless with an identity matrix. A significance value <0.05 indicates that the data DO NOT produce an identity matrix and are thus appropriately multivariate normal and acceptable for FA (George and Mallery, 2003). The data within this study returned a significance value of 0.000, indicating that the data was acceptable for FA. When the original 14 characteristics were analysed by the Principal Component Analysis (PCA) with Varimax rotation, three characteristics extracted from the analysis with an Eigen value greater than or equal to 1, which explained 53.973 percent of the total variance, presented in Table 2

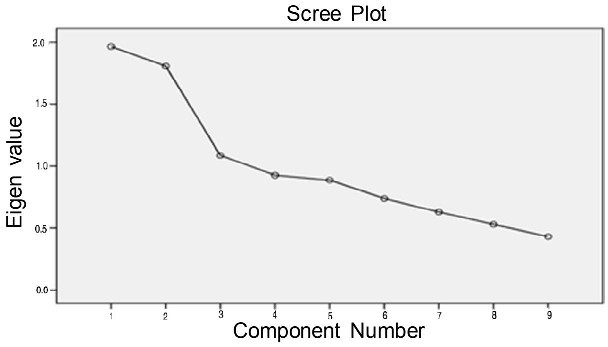

Figure 1: Plot of the Eigen values

The result of the Factor Analysis is presented in Table 3 and figure 1

Table 3. Component Matrix[a]

	Component		
	1	2	3
I feel that establishment of agro based enterprise is unproductive	0.773		
Agro based enterprise is useful in solving un-employment problem	0.636		
I think that it is difficult to follow legal procedure for agro based enterprise	0.545		
I prefer to have service but not own agro based enterprise		-0.737	
Agro based enterprise is a best option to earn money for landless rural people	0.308	0.689	
I prefer to be a part of agro based enterprise than other enterprise		0.383	-0.307
I think that agro based enterprise can be a good source of income for low inventors		0.522	0.572
Agro based enterprise is a best source of employ ment for irrespective level of educated rural youth	0.491	0.369	-0.517
I don't like to advice any one to become entrepreneur	0.421	-0.316	-0.477

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

The study revealed (as presented in Table 3), that the factor loadings are ranged from 0.773 to 0.308. The higher a factor loading, the more would its test reflect or measure as characteristics. The characteristic getting highest loading becomes the title of each group of characteristics e.g. Establishment of agro based enterprise is unproductive– title of characteristics group I and likewise. Further, the present study has interpreted the characteristics loaded by variables having significant loadings of the magnitudes of 0.50 and above (Pal, 1986; Pal and Bagi, 1987).

Characteristics group I: One characteristic with 0.773 belonged to Establishment of agro based enterprise is unproductive and another characteristic with 0.636 belonged to Agro based enterprise is useful in solving unemployment problem.

Characteristics group II: One characteristic with 0.689 belonged to Agro based enterprise is a best option to earn money for landless rural people.

Characteristics group III: One characteristic with 0.572 belonged to agro based enterprise can be a good source of income for low investors.

Ranking of the above characteristics in order of their importance, along with factor score, is shown in Table 4. The importance of these characteristics, as perceived by the respondents, has been ranked on the basis of factor score.

As depicted in Table 4, the characteristics: Agro based enterprise is a best option to earn money for landless rural people, Agro based enterprise can be a good source of income for low investors, establishment of Agro based enterprise is unproductive got the ranks of first, second and third respectively and constitute the key characteristics of Agriculture towards Agri Entrepreneurial ship.

Table 4. Ranks

	Mean Rank
I think that agro based enterprise can be a good source of income for low investors	2.00
I feel that establishment of agro based enterprise is unproductive	1.95
Agro based enterprise is a best option to earn money for landless rural people	2.05

Kendall's W Test is referred to the normalization of the Friedman statistic. Kendall's W is used to assess the trend of agreement among the respondents. To test the agreement of various respondents with respect to three key characteristics, Kendall's co-efficient is calculated and the result of the study is given in Table 5.

Ho : There is no difference in mean ranks for repeated measures.

H_1 : A difference exists in the mean ranks for repeated measures

Table 5:Test Statistics

N	120
Kendall's W[a]	0.003
Chi-Square	0.822
df	2
Asymp. Sig.	0.663

a. Kendall's Coefficient of Concordance

Kendall's W = 0.003 from Table 5.The study revealed that there is complete disagreement between the raters regarding Agro based enterprise is a best option to earn money for landless rural people, Agro based enterprise can be a good source of income for low investors, establishment of Agro based enterprise is unproductive.

Further, similar analysis was done to test whether there is agreement among the respondents with respect to ranking each of the attributes under Risk Orientation, Market Orientation, Achievement, Innovativeness, and Decision making ability. The study revealed that there is strong agreement among the respondents with respect to ranking each of the attributes under Risk Orientation as Kendall's W = 0.59 & moderate agreement with respect to ranking the attributes under Market Orientation with W = 0.292. There is no agreement among the respondents with respect to ranking each of the attributes under Achievement Orientation, Innovativeness, Decision making ability since Kendall's W = 0.113,0.182,0.064 respectively.

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Research Article
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PATTERNS OF CHICKEN MEAT AND EGG CONSUMPTION IN RURAL HOUSE HOLDS OF JAGITIAL DISTRICT OF TELANGANA STATE

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ABSTRACT

The consumption patterns of chicken meat and egg was studied in Jagitial district of Telangana on a sample size of 300 households. The results of the study concluded that most of the population is consuming chicken meat when compared to mutton, pork and fish. Majority of the respondents consuming 1 kg broiler meat/household/time and 3-5 eggs/ household/time. Majority of the respondents were spending 100-250 rupees for purchasing chicken meat/household/time. Majority of the households preferred chicken curry as utilization product followed by fry, biryani and kheema. Most of the people do not know the nutritive value of meat and egg.

Many of the developing countries are expected to undergo transformation in their economy and rapid urbanization over the next 30 years. India's poultry industry has transformed from a mere backyard activity into a major commercial activity. India, the world's second largest developing country, is contributing to the expansion of the poultry sector through its rapid growth. Meat consumption has shifted over time from beef, veal, lamb, mutton and chevon to a greater consumption of poultry and fish due to changing tastes, costs and income (Akbay and Boz 2005). This investigation focused on rural household chicken meat and egg consumption levels and patterns of Jagitial district. Even though many studies existed on animal product consumption, most of them were focused on urban household animal product consumption in relatively small cities. This paper is an attempt in that direction to address the issue of chicken meat and egg consumption in rural households of Jagitial district of Telangana.

MATERIALS AND METHODS

The objective of this study is to know the chicken meat and egg consumption patterns in rural households in Jagitial district of Telangana. The main source of this study is data obtained over a period of 4 months from August to November 2016. During this period data was collected from 300 households of 20 villages in 9 mandals of Jagitial district. A single visit was made to each household. Using pretested structured interview schedule, the respondents were personally interviewed and the data was collected. The data presented in tables was expressed in frequency and percentage.

Table 1. Chicken meat and Egg Consumption patterns in Jagitial district of Telangana

Particulars	Frequency n=300	Per centage (%)
Family size		
<5 members	192	64.0
>5 members	52	17.3
5 members	56	18.7
Meat of choice		
Chicken	251	83.7
Mutton & Chevon	41	13.7
Pork	7	10
Beef	1	1
Frequency of chicken meat consumption		
Weekly twice	15	5.0
Weekly once	89	29.7
Fortnightly	95	31.7
Monthly	101	33.7
Frequency of egg consumption		
Weekly twice	95	31.7
Weekly once	172	57.3
Fortnightly	24	8.0
Monthly	9	3.0

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Particulars	Frequency n=300	Per centage (%)
Reasons for consumption of meat		
Taste	241	80.3
Habituated	20	6.7
Demand by children	12	4.0
Because of guests	27	9.0
Total Chicken consumption/ household/time		
1 Kg	225	75.0
1.5 Kg	52	17.3
2 Kg	12	4.0
>2 Kg	11	3.7
Total number of eggs consumption/ house hold/time		
3-5 eggs	213	71.0
5-7 eggs	45	15.0
8-10 eggs	32	10.7
>10 eggs	10	3.3
Reasons for less / non consumption of meat and egg		
Religious sentiments	255	85.0
Dislike	10	3.3
Less availability	35	11.7
Utilization of chicken		
Curry	236	78.7
Fry	47	15.7
Biryani	10	3.3
Kheema	7	2.3
Total expenditure/household/time in rupees		
100-250	212	70.7
250-350	72	24.0
>400	16	5.3
Awareness about the nutritive value of meat and egg		
Known	62	20.7
Not Known	238	79.3
Type of Meat	**Rank**	
Broiler meat	1	
Native birds meat	2	
Mutton	3	
Rajasri, Giriraja and vanaraja etc	4	
Fish	5	
Pork	6	
Beef	7	
Type of Eggs		
Commercial eggs	1	
Native birds eggs	2	
Rajasri, Giriraja and vanaraja etc	3	
Duck eggs	4	
Season		
Winter	1	
Monsoon	2	
Rainy season	3	
Summer	4	

RESULTS AND DISCUSSION

The meat and egg consumption patterns of the rural households of Jagitial district were presented in Table 1. Majority of the farmers were marginal (60.5%) followed by agriculture labour (25.5%), small farmers (9.5%) and big farmers (4.5%) respectively. They had a family size of less than 5 members (64.0%), more than 5 members (17.3%) and 5 members (18.7%). From the study, it was revealed that most of the people preferred chicken meat (83.7%) followed by mutton and chevon (13.7%) and very less percentage of people preferred to take pork (10%) and beef (1.0%). Similar type of results were reported by Srinivasa and Thammiraju (2010), Nagaraja kumari et al. (2011) and Thammiraju and Surya Narayana (2005). The data revealed that most of the rural people were consuming chicken meat monthly once (33.7%) followed by fortnightly (31.7%), weekly once (29.7%) and weekly twice (5%). These findings were partially in line with findings of Thammiraju and Suryanarayana (2005) who revealed the respondents under their study were consuming chicken twice in a fortnight. With respect to frequency of egg consumption, 57.3% of the respondents consumed eggs weekly once, followed by weekly twice (31.7%), fortnightly (8%) and Monthly (3%). The difference in the frequency of consumption of chicken meat and egg is mainly because of its cost and non availability in rural areas. The major reasons for consumption of meat were because of its taste (80.3%), habituated (6.7%), because of guests (9%) and demand by children (4.0%). Majority (75%) of the respondents had an average consumption of 1 kg broiler meat /household/time and 17.3 per cent of the respondents consumed 1.5 kg and 4 per cent of the respondents consumed 2 kg and very few respondents consumed more than 2 kg of chicken meat/household/ time. Majority (71%) of the households consumed 3-5 eggs/time, followed by 5-7 eggs (15%), 8-10 eggs (10.7%) and very few households consumed more than 10 eggs/time (3.3%). Reasons for less consumption of meat and egg is due to religious sentiments (85%) followed by less availability (11.7%) and dislike (3.3%). Majority (70.7%) of the respondents spent 100-250 rupees for purchasing chicken meat/household/time followed by 250-350 rupees/household (24%) and more than 400 rupees/ household (5.3%). In accordance with findings of Nagaraja kumari et al. (2011) who reported that the consumption was higher at households with an investment of 151-200 rupees per month, preference owing towards festivals and occasions.

Majority (78.7%) of the households preferred curry as utilization product followed by fry (15.7%), biryani (3.3%) and kheema (2.3%). Most of the people (79.3%) does not know the nutritive value of meat and egg where as 20.7% of the individuals expressed that meat and egg in their diet will give them some energy and protein. Similar results were reported by Jagadeesh Babu *et al*. (2010). Analysing the preference ranking of meat, the respondents had ranked the broiler meat (rank 1) as highly preferred meat followed by native bird meat (rank 2), Mutton (rank 3), colored bird meat (rank 4), Fish (rank 5), Pork (Rank 6) and Beef (Rank 7). Analysing the preference ranking of type of eggs, the respondents had ranked the commercial eggs (rank 1) as highly preferred eggs followed by native bird eggs (rank 2), colored bird eggs (rank 3) and Duck eggs (Rank 4). All the respondents preferred to eat meat in winter followed by monsoon, rainy season and summer.

CONCLUSION

The present study revealed that majority of the respondents preferred broiler meat and commercial eggs. Majority of the respondents consuming 1 kg broiler meat/household/time and 3-5 eggs/ household/ time. Due to lack of proper education majority of the people do not know about the nutritive value of meat and egg. The respondents had ranked the broiler meat as first and highly preferred meat followed by native bird meat.

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Research Article
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IN VITRO PROTEIN DIGESTIBILITY OF MILLET BASED SOUTH INDIAN BREAKFAST PREPARATIONS

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ABSTRACT

Millet grains are now receiving specific attention from the point of nutrition security and the importance of utilization millets as food is increasing in the 21st Century. Six varieties of millets have been developed and standardized to serve as most common breakfast dishes namely idly, dosa and upma using traditional recipe. The overall mean IVPD of idlys from 6 millets was 78.67±4.36% and IVPD of millet idly was significantly high (P<0.01) compared to the respective mean IVPD of millet dosa and millet upma in the decreasing order. Mean IVPD of dosa breakfast from 6 millets was 71.51±6.58% and the *in vitro* protein digestibility of millet dosa was significantly higher than IVPD of millet upma (P<0.01) but significantly low compared to millet idly (P<0.01), indicating that millet dosa stands next to millet idly in its protein digestibility. The mean IVPD of upma from 6 millets was 61.76 ± 2.43% and it was significantly lower (P<0.01) than that of millet idly and dosa. Fermentation in idly and dosa batters improved IVPD to a great extent. The *in vitro* protein digestibility of proso millet and foxtail millet products was high compared to pearl millet, little millet, sorghum and finger millet. Higher *in vitro* protein digestibility of proso millet upma may be due to the low anti-nutrients and inhibitors like phyates and polyphenol content of proso millet.

Millets have immense production potential with minimum inputs. Millet is one of the most important drought-resistant crops and the sixth cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, and has short growing season, and better productivity under drought conditions, compared to major cereals. India is the world's leading producer of millets. However, in India, the area under millets including sorghum millet, pearl millet, finger millet and small millets is lesser compared to staple cereals, namely rice (45.53 Mha) and wheat (27.75 Mha). Similarly, total production of millets was 20.39 Mt and much lower than rice and wheat which accounted to 120.12 Mt and 90.75 Mt, respectively in 2012 (FAO 2012). Traditionally millets were important staple foods in the diets of Asians and Africans.

With enormous cereal production, millets became the forgotten food, leaving a wide gap in nutrition security. Realizing the excellent nutritional quality and health benefits of millets, people are showing an inclination to incorporate millets into their diet. Traditionally millets were used just for making porridges or cooked as rice. To improve millet consumption, there is a need to introduce millets into various meals.

Millet grains are now receiving specific attention from the developing countries in terms of utilization as food (Li *et al.,* 2008) Millets are considered as crop of food security because of their sustainability in adverse agro-climatic conditions (Usha Kumari *et al.,* 2004). These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security (Mal *et al.,* 2010). Along with nutrition, millets offer health benefits in daily diet and help in the management of disorders like diabetes mellitus, obesity and hyperlipidemia (Veena 2004).

It is remarkable that despite millet grains being an ancient food, research on millet and its food value is in its infancy and its potential vastly untapped. Research results so far are promising, showing the grain to have great versatility and more and more uses for millet are being discovered every year, including its potential benefits. The requirement of people for high quality, ready-to-eat foods of traditional nature with modem technological application has become a necessity; both from the economy point of view and to reduce the losses of seasonal agricultural produce (Ghosh *et al.,* 2001).

Digestibility of protein may be used as an indicator of protein availability. It is essentially a

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measure of the susceptibility of protein to proteolysis. A protein with high digestibility is potentially of a better nutritional value than one of low digestibility, because it would provide more amino acids for absorption on proteolysis. Their function in nutrition is to supply adequate amounts of needed amino acids. The protein nutritional quality of food depends on content, digestion, absorption, and utilization of amino acids. However, there is growing emphasis for improvement of protein quality and quantity in cereal crops. Attempts have been made to fortify these cereals with legumes (FAO, 1995).

Hima Bindu and Sumathi (2003) prepared common Indian traditional products namely muruku, chegodi, dosa, chapathi, laddu and payasam by incorporating Foxtail millet. All the products were acceptable. It was suggested that nutritious Foxtail millet could be exploited for the nutritional benefits and value added nutritive health foods. Barnyard and Kodo millet based chapathi and dosa and two commercial products viz., noodles and rusk were developed by Poongodi *et al.* (2010). Millet along with wheat flour and defatted soy flour in varying proportions were used. The acceptable levels of incorporation of millet flour were reported to be 20% for noodles and 30% for rusk, chapathi and dosa.

Idli and dosa are the most widely consumed fermented foods in India. Other fermented foods are also quiet popular and consumed all over the world because of the importance as human food (Mugocha *et al.* (2000); Gotcheva *et al,* (2001). Fermentation modifies the chemical composition of the grains of millet and thus the food products manufactured from it. This process also contributes to the reduction in the level of anti-nutritional components and enhances the in vitro protein digestibility. It has also been observed that pearl millet when processed and then fermented shows the same significant reduction of anti-nutritional components along with increase in IVPD (Hassan *et al.* (2006). Pearl millet when fermented leads to chemical changes in its composition like ash content, moisture content, fat, fibre and protein and also causes marked reduction in minerals like potassium, sodium, copper, magnesium, zinc, iron etc. (Ahmed *et al.*, 2009). High protein digestibility is observed when pearl millet germinated in ground is fermented, which accounts for 90%.

Fermentation not only improved the taste but at the same time enriches the food value in terms of protein, calcium and fibre, B vitamins, in vitro protein digestibility and decreased the levels of anti-nutrients in food grain (Maha *et al.,* 2003; Verma and Patel, 2013).

Pepsin- pancreatin (two step) digestibility of native pearl millet was shown to be 46% which reduced to 33% upon boiling and to 44% upon pressure cooking. However, another pearl millet variety showed mixed results in the same study. Therefore, millet variety, cooking conditions and 68% enzymatic digestion procedure were considered to be some important factors that affect IVPD (Devi *and Sumathi,* 1997; Abdel-al 2008; Pushparaj and Asna, 2011).

The digestibility of cooked sorghum gruel was reported to be lower than that of cooked gruels made with wheat, maize, rice and millet. The pepsin protein digestibility of decorticated, heat extruded sorghum was higher than whole sorghum gruels. Ramachandra(*et al.*1977). The IVPD of cereals and millets reported by Rajyalakshmi and Geervani (1990) indicated a reduction of 9 to 24 percent due to boiling.

MATERIALS AND METHODS

The selected six millets, namely pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*) and sorghum (*Sorghum bicolor*) were procured from Grameenmall Foundation, ALEAP Industrial Estate, Gajularamaram, Hyderabad, Telangana. Pearl millet, finger millet and sorghum grains were obtained in whole form as they are edible with hull, while foxtail millet, little millet and proso millet were obtained in dehulled form. All six millets were also obtained in the form of semolina to suit some of the preparations.

Three most common South Indian breakfast dishes namely idly, dosa and upma were developed with each of the six millets using the traditional basic recipe. To standardize the recipes with millets, variations in proportions of main ingredients and soaking time were tried and the products were subjected to acceptability studies and highly acceptable recipe was taken for preparation of final idly, dosa and upma. Millet idly was prepared from black gram dhal: millet semolina in the ratio of 1:2 respectively and dosa was prepared from black gram dhal: edible whole millet grain in the ratio of 1:2 and Upma was made from millet semolina.

The products were subjected to analysis of protein and *in vitro* protein digestibility on dry weight basis.

Analysis of protein

Dehydrated and finely powered idly, dosa and upma samples of each of the six millets were initially analyzed for protein, so as to take sample containing 6.75 ± 0.1mg of nitrogen for estimation of protein digestibility.

The crude protein content of the sample was estimated according to the Micro Kjeldhal Method (AOAC, 2005) and calculated as percent nitrogen of product and multiplied with 6.25 to obtain the protein content.

For estimation of protein, 0.5g of each sample was weighed in to the digestion tube and five grams of digestion mixture (98g of potassium sulphate + 2g copper sulphate) plus 10.00 ml of concentrated H_2SO_4 were carefully added and the samples were placed in the digestion unit for 1½ hr at 375°C.

In a 100 ml conical flask, 40.00 ml of 4% boric acid was added along with few drops of mixed indicator containing (1ml of 0.2% bromocresol green + 3 ml of 0.2% methyl red). Distillation was done for10 minutes in the Kjeldhal distillation apparatus adding 15.00 ml of 40% NaOH and steaming for 10 seconds. The contents collected in conical flask were blue in color after distillation was completed. Titration was done with standard 0.1N HCl till the contents of the flask turned to pink color. A blank was run simultaneously.

$$\%\ \text{Nitrogen} = \frac{\text{(S-B)x Normality of HCL x14x100}}{\text{Weight of the sample taken x100}}$$

S=Sample titre value
B= Blank titre value

Protein content (g) = Per cent nitrogen x 6.25

***In Vitro* Protein Digestibility**

In vitro protein digestibility (IVPD) method was developed to simulate the conditions in the digestive tract of human gastro intestinal tract. This method has the potential to give useful measures of *in vivo* amino acid and protein digestibility for humans. This was estimated according to the procedure of Singh and Jambunathan (1981).

An amount of sample containing 6.75±0.1mg nitrogen was placed in a 50ml conical flask and 5ml of pepsin solution was added. The flask was incubated in a water bath shaker for 16hr at 37^0C. Then 2ml of pancreatin solution was added and the contents were further incubated for 24hrs at 37^0C. Then 2 to 3 drops of toluene was added during incubation and samples were stirred slowly on a mechanical shaker. After 24hrs, the reaction was stopped by adding 20ml of 10% of TCA and the suspension was centrifuged. The residue was washed twice with 5% TCA. An aliquot of 5ml was taken and evaporated to dryness at low temperature (80-90^0C) and nitrogen content was determined by the Micro Kjeldal procedure. Then digestive of each sample was calculated in the following way.

$$\text{IVPD} = \frac{\text{(N in sample supernatants - N in Blank)}}{\text{N in starting material}} \text{x100}$$

RESULTS AND DISCUSSION

The *in vitro* protein digestibility (IVPD) of finger millet, foxtail millet, little millet, pearl millet, proso millet and sorghum prepared into breakfast foods namely idly, dosa and upma is given in table1 along with the analysis of variance between the products and between the millets.

The *in vitro* protein digestibility of millet idly ranged between 73.54% from little millet to 85.00% from foxtail millet. The protein digestibility of millet idly in the decreasing order was 85.00% from foxtail millet, 81.34% from proso millet, 79.53% from finger millet, 78.56% from sorghum, 74.07% from pearl millet and 73.54% from little millet idly. The overall mean IVPD of idlys from 6 millets was 78.67±4.36% and IVPD of millet idly was significantly high ($P<0.01$) compared to the respective mean IVPD of millet dosa and millet upma in the decreasing order. Protein digestibility of millet idly was the best among the three millet breakfast items followed by millet dosa and millet upma (fig.1). Higher protein digestibility of foxtail based idly and proso millet idly may be attributed to the lower antinutrient content of phyticacid and polyphenols compared to pearl millet, little millet, finger millet and sorghum. Findings of the present study are similar to the results reported by Balasubramanian *et al.* (2012) on the nutritional composition of pearl millet based idly.

Table 1. ***In vitro*** **protein digestibility of millet breakfast dishes**

In vitro protein digestibility (%)				
Millets	**Idly**	**Dosa**	**Upma**	**Millet wise Mean ± SD**
Finger millet	79.53	61.36	58.99	**66.63 ± 11.24**
Foxtail millet	85	80.7	61.18	**75.63 ± 12.69**
Little millet	73.54	72.77	62.66	**69.65 ± 6.07**
Pearl millet	74.07	72.27	61.36	**69.23 ± 6.87**
Proso millet	81.34	74.61	66.05	**74.00 ± 7.67**
Sorghum	78.56	67.34	60.29	**68.73 ± 9.21**
Product wise Mean ± SD	**78.67 ± 4.36^{c}**	**71.50 ± 6.58^{b}**	**61.75 ± 2.43^{a}**	

Note: From ANOVA, C.D of Millets @ 5% level is 'Not significant'; C.D of Products @ 1% level = 5.22**

The *in vitro* protein digestibility of different millet based dosas ranged between 61.36% from finger millet to 80.70% from foxtail millet dosa. The protein digestibility of millet dosa in the decreasing order was 80.70% from foxtail millet, 74.61% from proso millet, 72.77% from little millet, 72.27% from pearl millet, 67.34% from sorghum and 61.36% from finger millet dosa. The overall mean IVPD of dosa breakfast from 6 millets was 71.51±6.58%, and the *in vitro* protein digestibility of millet dosa was significantly higher than IVPD of millet upma ($P<0.01$) but significantly low compared to millet idly ($P<0.01$), indicating that millet dosa stands next to millet idly in its protein digestibility.

The IVPD of millet upma a popular breakfast preparation ranged between 58.99% from finger millet to 66.05% proso millet. The IVPD of upma from different millets in the decreasing order was 66.05% from proso millet, 62.66% from little millet, 61.36% from pearl millet, 61.18% from foxtail millet, 60.29% from sorghum and 58.99% from finger millet upma. The mean IVPD of upma from 6 millets was 61.76 ± 2.43% and it was significantly lower ($P<0.01$) than that of millet idly and dosa. The *in vitro* protein digestibility of proso millet upma was significantly higher. Comparatively *in vitro* protein digestibility of proso millet and foxtail millet was high with least difference between the two. Higher *in vitro* protein

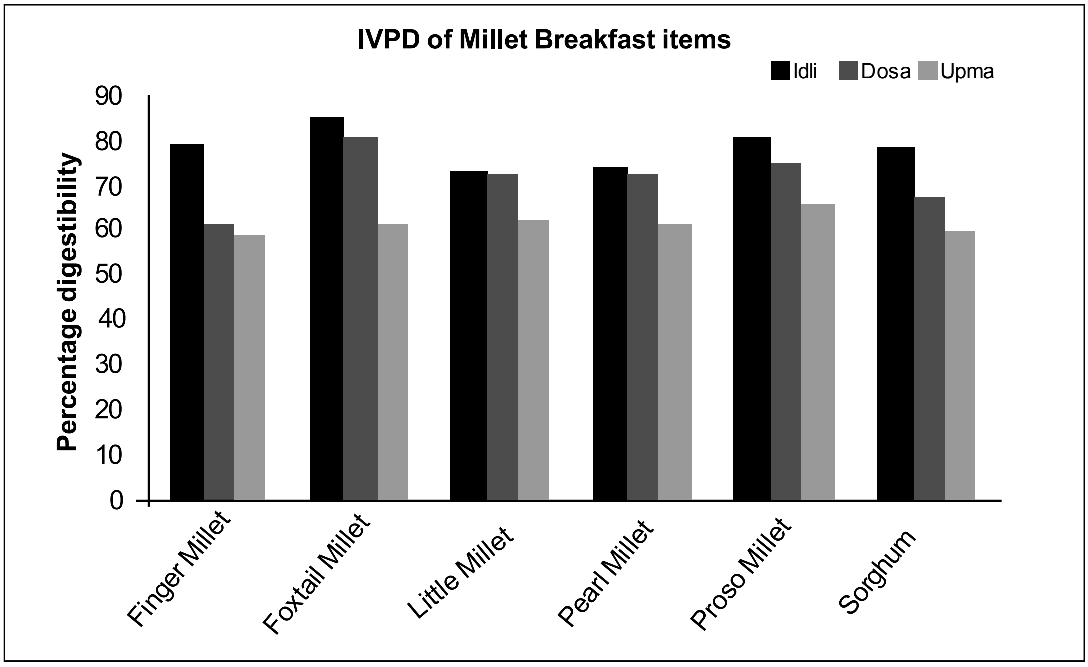

Fig.1: ***In vitro*** **protein digestibility of breakfast preparations of millet**

digestibility of proso millet upma may be due to the low antinutrients and inhibitors like phytates and polyphenol content of proso millet.

Comparison of IVPD of idly, dosa and upma made from each millet has shown that finger millet had slightly lower IVPD, followed by sorghum, pearl millet and little millet with a relatively higher IVPD from proso millet and foxtail millet preparations. On an overall basis, no significant difference was observed between the IVPD of different millets at 5% level.

The *in vitro* protein digestibility displayed in radar chart (Fig.2) shows the performance of different millets in different preparations by displaying which product and which millet was scoring high IVPD or low IVPD.

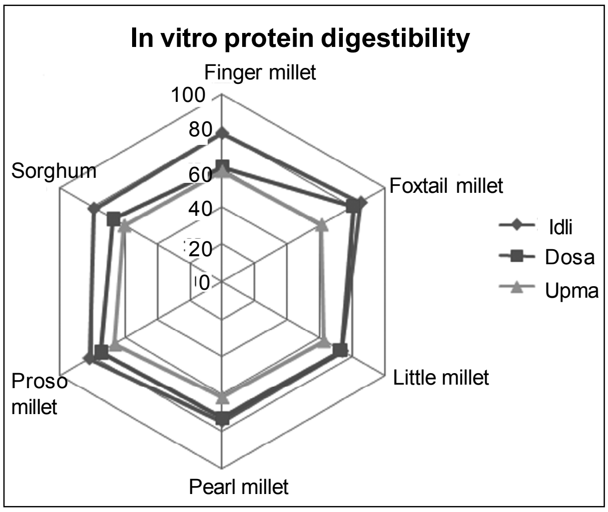

Fig.2 : Spread of IVPD of millet breakfast dishes

Digestibility of protein may be used as an indicator of protein availability. It is essentially a measure of the susceptibility of protein to proteolysis. A protein with high digestibility is potentially of a better nutritional value than one of low digestibility, because it would provide more amino acids for absorption on proteolysis (FAO,1995).

The steps of soaking, grinding and fermentation of batters as in idli and dosa preparations greatly enhanced *in vitro* protein digestibility when compared to boiling method employed for making upma. Steaming, subsequent to fermentation as in idli and open pan shallow frying as in dosa preparation has not affected IVPD of the two preparations. Several research studies proved this fact.

Idly and dosa are the most widely consumed fermented foods in India. Other fermented foods are also quiet popular and consumed all over the world because of the importance as human food (Mugocha *et al.,* 2000); Gotcheva *et al.,* 2001). Fermentation modifies the chemical composition of the grains of millet and thus the food products manufactured from it. This process also contributes to the reduction in the level of anti-nutritional components and enhances the in vitro protein digestibility. It has also been observed that pearl millet when processed and then fermented shows the same significant reduction of anti-nutritional components along with increase in IVPD (Hassan *et al.,* 2006). Pearl millet when fermented leads to chemical changes in its composition like ash content, moisture content, fat, fibre and protein and also causes marked reduction in minerals like potassium, sodium, copper, magnesium, zinc, iron etc. (Ahmed *et al.*, 2009). High protein digestibility was observed when pearl millet germinated in ground was fermented, which accounts for 90%.

Fermentation not only improved the taste but at the same time enriches the food value in terms of protein, calcium and fibre, B vitamins, *in vitro* protein digestibility and decreased the levels of anti-nutrients in food grain (Maha *et al.,* 2003; Verma and Patel, 2013).

Within the millets, finger millet had significantly lower IVPD than that of other five millets studied, which is in agreement with the studies of Elshazali *et al.* (2011) where the IVPD of the whole raw flour was 46.43 and 51.23 percent, while that of the dehulled raw flour 50.54 and 55.28 percent for two varieties of finger millet. However the IVPD can be higher depending upon the varieties as shown by Hag *et al.* (2002), where IVPD of two different pearl millet cultivars were reported as 72.7 and 70.4 percent. With respect to treatment effect higher IVPD was observed in the dehulled grains (54.86%) compared to whole grain. This was due to the established fact that, as the proportion of pericarp and germ material becomes less the IVPD improves (Duodu *et al.,* 2002; Chibber *et al.,* 1980). Dehulling decreases the anti-nutrients that interfere with the IVPD. Babiker and Eltinay, (1993) also reported the improvement in IVPD is likely due to reduction in antinutrients during traditional treatments. High molecular weight polyphenols are known to precipitate proteins, reduce protein digestibility and produce off-coloured products (Hulse *et al*., 1980).

Nutritional levels of food are of utmost importance according to human health prospects because nutritionally sufficient food will provide proper development and increment in genetic potential in man. Also for the solution of the large scale problem of insecurity of food and malnutrition, dietary quality is of major concern (Singh and Raghuvanshi, 2012).

CONCLUSION

Protein digestibility of millet idly was the best among the three millet breakfast items, followed by millet dosa and millet upma. Fermentation of millet idly and dosa batters has improved the protein digestibility. Proso millet and foxtail millet products had better IVPD with other millets following closely in their protein digestibility. The protein digestibility *in vitro* of the millet products proved millets to be a potential source of growth promoting protein with good digestibility. Hence, traditional rice based idly and dosa can be substituted with millet idly and dosa, similarly, wheat upma with non glutinous millet upma for better micronutrients and phytochemicals abundant in millets along with good protein digestibility.

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Research Article
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GREEN SYNTHESIS OF NANOPARTICLES FROM PLANT SOURCES FOR TEXTILE APPLICATION

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ABSTRACT

Textiles are infected very easily by microbes which create health problems to the consumers. To avoid and control the infection and infestation from micro organisms, antimicrobial finishes are given to them. There are a number of natural and synthetic antimicrobial agents that can be applied on textiles. In the present study an attempt was made to finish cotton textiles with nanoparticles from plant sources to impart the antimicrobial finish. Finish was applied to cotton knitted textiles using pad-dry-cure method with curing at 35° to 40°C. The antibacterial activity was evaluated by a modified qualitative test method AATCC-147, 2004 against both *Staphylococcus aureus* and *Escherichia coli*. It was found that all the treated samples with all combinations indicated better antibacterial resistance. Fabric treated with Cassia and silver nanoparticles were found to possess high antibacterial resistance.

In the present world most of us are very conscious about our hygiene and cleanliness. Clothing and textile materials are not only the carriers of microorganisms such as pathogenic bacteria, odour generating bacteria and mould fungi, but also good media for the growth of the microorganisms. Microbial infestation poses danger to both living and non living matters. Though the use of antimicrobials have been known for the decades, it is only in the recent couple of years several attempts have been made on finishing textiles with antimicrobial compounds. Antimicrobial finishing of textiles protects users from pathogenic or odor-generating microorganisms, which can cause medical and hygienic problems, and protects textiles from undesirable aesthetic changes or damage caused by rotting, which can result in reduced functionality (Gedanken *et al.* 2012). As a consequence of their importance, the number of different antimicrobial agents suitable for textile application on the market has increased dramatically. These antimicrobial agents differ in their chemical structure, effectiveness, method of application, and influence on people and the environment (Vyas *et al.* 2010).

The majority of antimicrobial agents in the textile industry utilize a controlled release mechanism. These agents, which are also called, leaching antimicrobials, are not chemically bound to the textile fibers and their antimicrobial activity decreases after several washes and gradually falls under the limit of effectiveness or even expire (Harini *et al.* 2007).

Nanotechnology has created a landmark in textile finishing. The combination of nanotechnology and textile surface modification provides a way to impart new and diverse properties to textiles while retaining comfort and mechanical strength. Currently, functional finishes on textile fabrics are of critical importance to improve textile products with multifunctional properties.

MATERIALS AND METHODS

Four plant sources Pomegranate, Cassia Periwinkle and Marigold leaves, possessing antibacterial property were synthesized using titanium dioxide, Zinc Oxide and Silver nitrate as a precursor with green synthesis method. The finish was applied to the fabric by pad- dry - cure method. The antibacterial activity of all treated fabric samples was evaluated by a modified qualitative test method AATCC-147, 2004 against *Staphylococcus aureus* and *Escherichia coli*. Zone of inhibition (*Zoi*) was calculated in mm.

RESULTS AND DISCUSSION

Based on the secondary data, an exhaustive list of plants having bacterial efficacy was prepared. Out of the prepared list, four plants having good bacterial resistance and availability in abundance were selected for the study. The antimicrobial efficacy was tested for twenty four nanoparticles which were prepared with different precursors with aqueous and ethanol extractions. The prepared nanoparticles are shown in the table 1 and figure 1.

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Table 1. Nanoparticles prepared with different precursors.

Pomegranate		Cassia		Periwinkle		Marigold	
Aqueous	Ethanol	Aqueous	Ethanol	Aqueous	Ethanol	Aqueous	Ethanol
TiO_2	TiO_2	TiO_2	TiO_2	TiO_2	TiO_2	TiO_2	TiO_2
Zno	Zno	Zno	Zno	Zno	Zno	Zno	Zno
$AgNO_3$	$AgNO_3$	$AgNO_3$	$AgNO_3$	$AgNO_3$	$AgNO_3$	$AgNO_3$	$AgNO_3$
T- Titanium, Z- Zinc, $AgNO_3$- Silver nitrate							

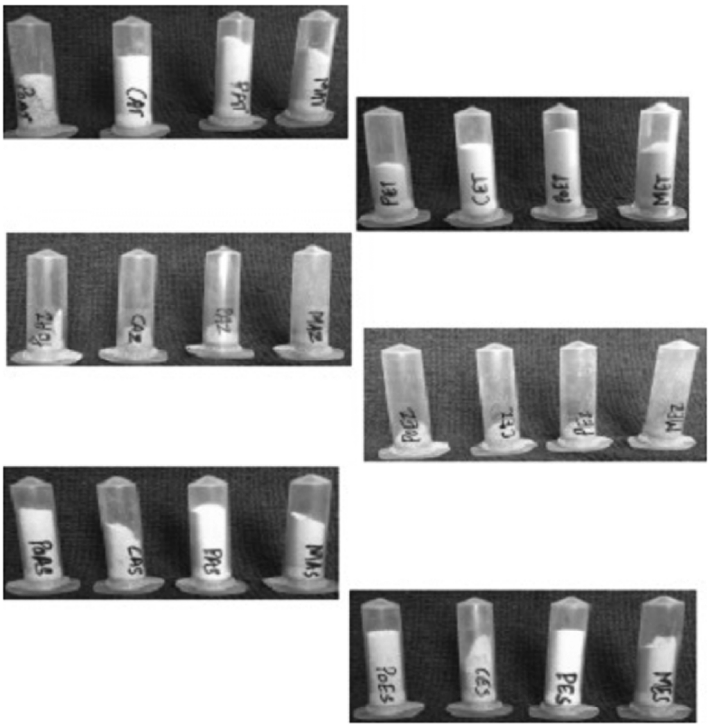

Fig. 1 : Green synthesized nanoparticles with aqueous and ethanolic extracts.

1. Antibacterial efficacy of prepared nanoparticles from selected plant sources with different extraction media.

Nanoparticles were synthesized using aqueous and ethanol extraction with four precursors were tested for antibacterial resistance against *Staphylococcus aureus* and *E. Coli.* (Shown in figure 2 to 4)

Table 2. Antibacterial efficacy of the nanoparticles.

	Zoi in mm											
	$AgNO_3$				TiO_2				Zno			
	Aqueous		Ethanol		Aqueous		Ethanol		Aqueous		Ethanol	
	S.A	*E.coli*	*S.A*	*E.coli*	*S.A*	*E.coli*	*S.A*	*E.coli*	*S.A*	*E.coli*	*S.A*	*E.coli*
Pomegranate	21	23	17	16	18	19	13	12	17	18	12	14
Cassia	31	33	24	24	26	28	20	21	22	23	21	22
Periwinkle	29	31	23	25	25	24	19	20	21	21	22	21
Marigold	21	23	18	19	16	18	12	13	16	17	14	16

The results in the table 2 revealed that the aqueous and ethanol extracts of various plants exhibited varied antimicrobial activity. The zone of inhibition observed with aqueous extracts of all plant sources was high compared to the ethanol extracts against to the both gram positive and gram negative cultures.

It was observed that the highest zone of inhibition was registered for all the plant sources with both the extraction methods with silver nanoparticles among all precursors and extraction methods.

It was also noticed that among the all plant sources with different extraction methods and precursors, Cassia and Periwinkle showed high zone of inhibition followed by Pomegranate and Marigold. It was noticed that silver nanoparticles of cassia with aqueous extraction registered high zone of inhibition against *E.coli* 33 mm and 31 mm for *S. aureus* and least was observed for titanium nanoparticles of pomegranate with ethanol extract against both the bacteria.

The aqueous extract of cassia exhibited strong activity i.e. 28 mm zone of inhibition for *E.coli* and 26 mm for *Staphylococcus aureus*. while zone of inhibition observed with its ethanol extract was 21 and 20 mm for *E.coli* and *Staphylococcus aureus*.

It was evident from the results that even though the antibacterial activity of all the plant sources with both the extraction methods were observed to be strong with slight variations. It was also observed from the results that amongst all the extracts tested for antibacterial efficacy, zone of inhibition of silver nanoparticles registered high followed by titanium and zinc nanoparticles.

These finding corroborated with the findings by (Kavimani *et.al* 2015). In their study antibacterial activity of *Cassia ariculata* linn. they found that the antibacterial activity of *C. auriculata* extract showed a clear zone of inhibition against five microorganisms such as *E.coli*, *Bacillus subtilis*, *Pseudomonas auregenosa*, *Streptococcus aureus* and *K. pneumonia*.

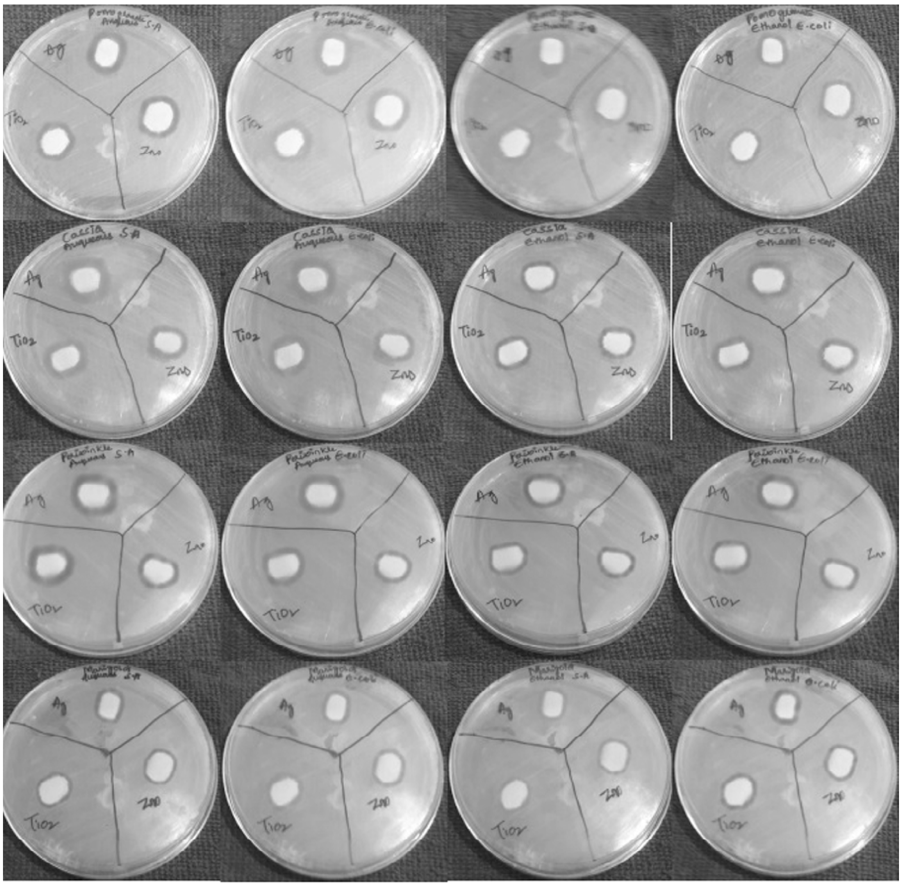

Fig. 2 : Zoi of nano treated fabrics with different media and extraction.

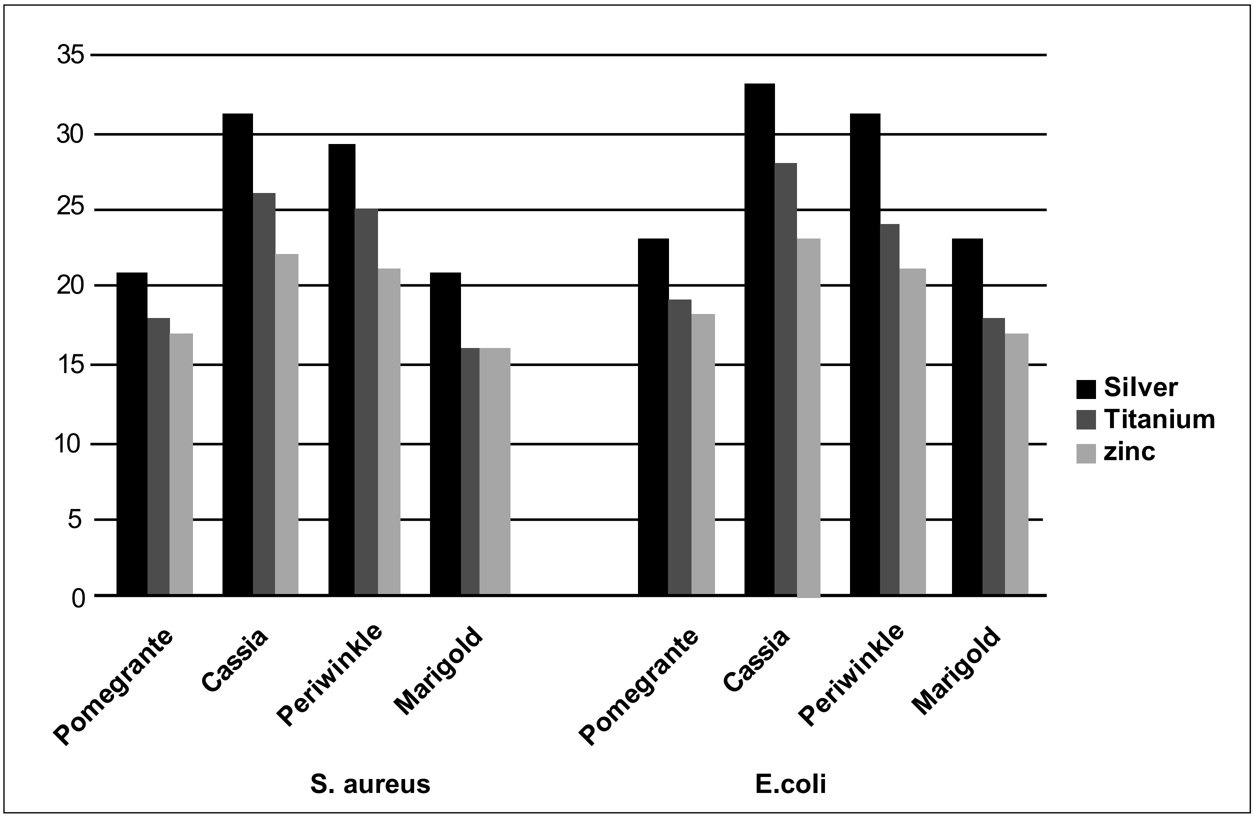

Fig. 3 : Antibacterial efficacy of the nanoparticles with aqueous extracts.

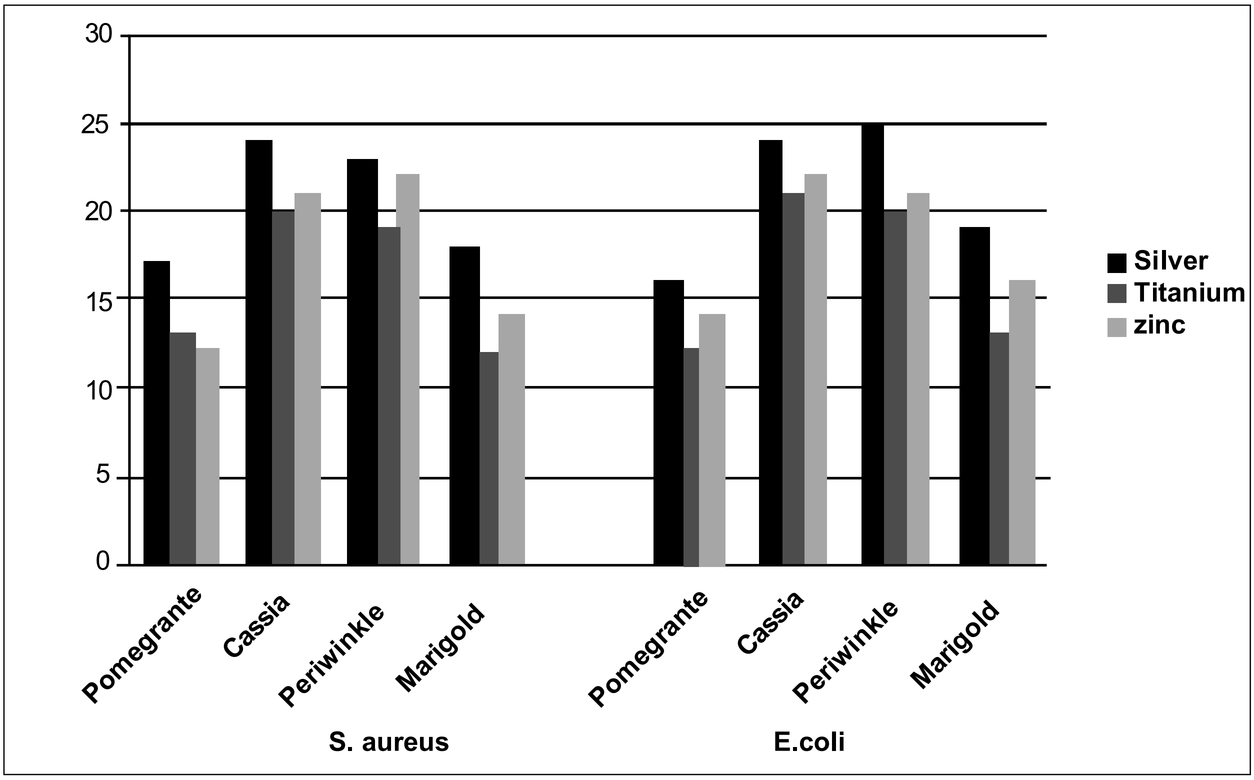

Fig. 4 : Antibacterial efficacy of the nanoparticles with ethanolic extracts.

CONCLUSION

There is a demand for eco friendly textiles because of growing needs of people in aspects of health and hygiene. This study indicated that green synthesized nanoparticles can impart to cotton knitted fabrics to achieve the better bacterial resistance. It was found that all the treated samples with all combinations indicated better antibacterial resistance. Fabric treated with Cassia and silver nanoparticles were found to possess high antibacterial resistance.

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Research Note
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CORRELATION AND PATH COEFFICIENT ANALYSIS FOR GRAIN YIELD IN AEROBIC RICE (*Oryza sativa* L.) GENOTYPES

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As rice is the staple food in most parts of India, to feed the increasing population there is a great need to increase production of rice and productivity of land under rice cultivation. In Asia, about 17 million ha of irrigated rice area may experience "Physical water scarcity" and 22 million ha may have "Economic water scarcity" by 2025 (Tuong and Bouman, 2003). Therefore, efficient use of water is required in rice production. Aerobic rice is one such new concept to decrease water requirement in rice production (Vijayakumar, 2006). However, crop yield is the end product of the interaction of a number of other interrelated attributes. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its component characters and also among themselves. Correlation gives only the relation between two variables whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921). In this study an attempt was made to identify the major contributing characters for grain yield, their direct and indirect effects.

The material for this study, consisted of 52 rice genotypes and were evaluated at Indian Institute of Rice Research (ICAR-IIRR), Rajendranagar, during *Kharif* 2016. The experiment was laid out in Randomized Block Design (RBD) with three replications. The crop was cultivated purely as aerobic rice, which does not require any puddling and flooding. The soil condition (moisture status) was maintained at below saturation level and throughout the crop growth it was maintained as irrigated dry crop. A plot size of two rows of 2m length for each entry with a spacing of 20 x 15 cm was maintained and later thinning was done retaining one seedling per hill after one week. The recommended package of practices and plant protection measures of IIRR was followed for raising a healthy crop. Data was recorded on eleven characters *viz.,* days to fifty per cent flowering, plant height, panicle length, number of productive tillers per plant, number of filled grains per panicle, spikelet fertility percentage, 1000 grain weight, productivity per day, biomass per plant, harvest index and grain yield per plant from each replication and the mean data were subjected to statistical analysis as per Singh and Chaudhary (1985) for Correlation coefficients and Dewey and Lu (1959) for path analysis.

In the present study, phenotypic and genotypic correlations between yield and yield components were estimated. In general, genotypic correlations were found to be higher than phenotypic correlations, which indicated that though there is strong inherent association between characters studied, its expression is lessened due to influence of environment on the association of characters at genic level.

Phenotypic and genotypic correlation coefficients between yield and yield components are presented in Table 1. Days to 50 per cent flowering had a significant positive phenotypic correlation with grain yield per plant, panicle length, number of productive tillers per plant, number of filled grains per panicle and harvest index. The plant height showed a significant positive phenotypic correlation with, grain yield per plant, number of filled grains per panicle, 1000 seed weight and biomass per plant, while negative and significant correlation of plant height was observed with number of productive tillers/ plant and harvest index. Panicle length exhibited a significant positive phenotypic correlation with number of filled grains per panicle, spikelet fertility and 1000 seed

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Table 1. Estimates of phenotypic and genotypic correlation coefficients for yield and its attributing characters

Character		Days to 50% flowering	Plant height	Panicle length	No. of Productive tillers per plant	No. of filled grains per panicle	Spikelet fertility	1000-seed weight	Productivity per day	Biomass per plant	Harvest Index	Grain yield per plant
Days to 50%	P	**1.0000**	0.1223	0.3431**	0.1594*	0.5331**	0.1150	-0.0195	0.0049	-0.0536	0.2191**	0.2472**
flowering	G	**1.0000**	0.1181	0.3730**	0.1691*	0.5421**	0.1149	-0.0229	0.0073	-0.0657	0.2280**	0.2570**
Plant height	P		**1.0000**	0.5653**	-0.4414**	0.3795**	0.1272	0.5292 **	0.1470	0.4604**	-0.2536**	0.1630*
	G		**1.0000**	0.6145**	-0.5199**	0.3892**	0.1301	0.5412**	0.1454	0.4798	-0.2621**	0.1605*
Panicle length	P			**1.0000**	-0.0258	0.3811**	0.2527**	0.1930 *	0.0041	-0.0205	0.0637	0.0774
	G			**1.0000**	0.0038	0.4071**	0.2706**	0.2060*	0.0242	0.0073	0.0654	0.1048
No. of Productive	P				**1.0000**	-0.0043	0.2021*	-0.3806 **	0.2308**	-0.3316**	0.4903**	0.2561**
tillers per plant	G				**1.0000**	-0.0029	0.2298**	-0.4340	0.2296**	-0.4530**	0.5749**	0.2585**
No. of filled grains	P					**1.0000**	0.5067**	0.0868	0.5112**	0.3200**	0.2694**	0.6261**
per panicle	G					**1.0000**	0.5088**	0.0874	0.5348**	0.3406**	0.2736**	0.6535**
Spikelet fertility (%)	P						**1.0000**	0.0613	0.4997**	0.0490	0.4247**	0.5043**
	G						**1.0000**	0.0615	0.5270**	0.0519	0.4359**	0.5301**
1000 seed weight	P							**1.0000**	0.1600*	0.2852**	-0.0689	0.1470
	G							**1.0000**	0.1656*	0.2999	-0.0697	0.1513
Productivity per day	P								**1.0000**	0.2902**	0.5785**	0.9681**
	G								**1.0000**	0.2391**	0.6147**	0.9662**
Biomass per plant	P									**1.0000**	-0.5619**	0.2585**
	G									**1.0000**	-0.5711**	0.2047*
Harvest index (%)	P										**1.0000**	0.6174**
	G										**1.0000**	0.6549**

P- Phenotypic correlation coefficient, G- Genotypic correlation coefficient ; ** Significant at 1%, * Significant at 5 %

weight. Number of productive tillers per plant exhibited significant positive phenotypic correlation with grain yield per plant, spikelet fertility, productivity/ day and harvest index while significant negative correlation with 1000 seed weight and biomass per plant. The significant positive phenotypic correlation of days to 50 percent flowering, plant height and number of productive tillers per plant with grain yield per plant was also reported earlier by Patel *et al* (2014) and Srijan *et al* (2016).

Number of filled grains per panicle and , spikelet fertility % exhibited a significant positive phenotypic correlation with grain yield per plant, productivity/ day and harvest index. 1000 grain weight has positive significant correlation with productivity/ day and biomass/ plant. Productivity per day exhibited a significant positive phenotypic correlation with grain yield per plant, biomass/ plant and harvest index. Bhadru *et al.* (2011) and Srijan *et al.* (2016) also reported significant positive phenotypic correlation of productivity per day with, grain yield per plant. Biomass per plant and harvest index showed significant positive correlation with grain yield per plant whereas biomass per plant showed significant negative correlation with harvest index.

As simple correlation cannot provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. The estimates of path coefficient analysis are provided for yield and yield component characters in Table 2. Among all the characters productivity/ day was the major contributor for grain yield followed by days to 50 per cent flowering, number of filled grains per panicle and 1000 seed weight. These characters showed direct positive effects on grain yield per plant. On the other hand characters that had negative direct effect include, spikelet fertility, panicle length, number of productive tillers per plant, plant height, harvest index and biomass per plant. The positive indirect effects of various characters with grain yield include Days to 50 per cent flowering through number of filled grains per panicle, productivity/ day and biomass per plant; plant height through days to 50 per cent flowering, number of productive tillers/ plant, number of filled grains per panicle, 1000 seed weight, productivity/ day and harvest index. Panicle length through days to 50 per cent flowering, number of productive tillers per plant, number of filled grains per panicle, productivity/ day, 1000 grain weight and biomass per plant; Number of productive tillers per plant through days to 50 per cent flowering, plant height, panicle length, productivity/ day and biomass per plant; Number of filled grains per panicle through days to 50 per cent flowering, number of productive tillers per plant, 1000 grain weight and productivity/ day; Spikelet fertility through days to 50 per cent flowering, number of filled grains per panicle, productivity/ day and 1000 grain weight; 1000 grain weight through number of productive tillers per plant, number of filled grains per panicle, productivity/ day and harvest index; Productivity per day through days to 50 per cent flowering, panicle length, number of filled grains per panicle and 1000 - grain weight; Biomass per plant through panicle length, number of productive tillers per plant, number of filled grains per panicle and 1000 grain weight; and Harvest index through days to 50 per cent flowering, plant height, number of filled grains per panicle, productivity/ day and biomass per plant. Bhadru *et al.* (2011) and Srijan *et al.* (2016) reported the positive direct effects of productivity/ day, days to 50 per cent flowering, number of productive tillers per plant, number of filled grains per panicle, 1000 grain weight and negative direct effects of spikelet fertility percent on grain yield per plant.

The study of phenotypic correlation studies revealed that selection of plants with more number of productive tillers per plant, higher number of filled grains per panicle, more 1000 grain weight, high productivity per day, more biomass per plant, tall plants with long duration would result in improvement of yield. Path analysis revealed that productivity/ day, days to 50 per cent flowering, number of filled grains per panicle and 1000 grain weight are the most important characters which could be used as selection criteria for effective improvement in grain yield. Therefore, it is suggested that preference should be given to these characters in selection programmes, so as to isolate superior lines with high genetic potential in rice.

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Table 2. Direct and indirect effects of various component characters on yield in rice

Character		Days to 50% flowering	Plant height	Panicle length	No. of Productive tillers per plant	No. of filled grains per panicle	Spikelet fertility	1000-seed weight	Productivity per day	Biomass per plant	Harvest Index	Grain yield per plant
Days to 50% flowering	P	**0.2451**	-0.0015	-0.0035	-0.0018	0.0132	-0.0012	-0.0001	0.0049	0.0030	-0.0110	0.2472**
	G	**0.2522**	-0.0018	-0.0040	-0.0023	0.0157	-0.0011	-0.0002	0.0073	0.0041	-0.0128	0.2570**
Plant height	P	0.0300	**-0.0123**	-0.0058	0.0048	0.0094	-0.0013	0.0031	0.1482	-0.0260	0.0128	0.1630*
	G	0.0298	**-0.0153**	-0.0066	0.0072	0.0112	-0.0012	0.0041	0.1465	-0.0298	0.0147	0.1605*
Panicle length	P	0.0841	-0.0069	**-0.0102**	0.0003	0.0094	-0.0025	0.0011	0.0042	0.0012	-0.0032	0.0774
	G	0.0941	-0.0094	**-0.0108**	-0.0001	0.0118	-0.0025	0.0015	0.0243	-0.0005	-0.0037	0.1048
No. of Productive tillers per plant	P	0.0391	0.0054	0.0003	**-0.0110**	-0.0001	-0.0020	-0.0022	0.2327	0.0187	-0.0247	0.2561**
	G	0.0426	0.0080	0.0000	**-0.0138**	-0.0001	-0.0022	-0.0033	0.2314	0.0282	-0.0323	0.2585**
No. of filled grains per panicle	P	0.1307	-0.0047	-0.0039	0.0000	**0.0247**	-0.0051	0.0005	0.5154	-0.0181	-0.0136	0.6261**
	G	0.1367	-0.0060	-0.0044	0.0000	**0.0289**	-0.0048	0.0007	0.5389	-0.0212	-0.0154	0.6535**
Spikelet fertility (%)	P	0.0282	-0.0016	-0.0026	-0.0022	0.0125	**-0.0100**	0.0004	0.5038	-0.0028	-0.0214	0.5043**
	G	0.0290	-0.0020	-0.0029	-0.0032	0.0147	**-0.0094**	0.0005	0.5311	-0.0032	-0.0245	0.5301**
1000 seed weight	P	-0.0048	-0.0065	-0.0020	0.0042	0.0021	-0.0006	**0.0058**	0.1613	-0.0161	0.0035	0.1470
	G	-0.0058	-0.0083	-0.0022	0.0060	0.0025	-0.0006	**0.0075**	0.1669	-0.0186	0.0039	0.1513
Productivity per day	P	0.0012	-0.0018	0.0000	-0.0025	0.0126	-0.0050	0.0009	**1.0082**	-0.0164	-0.0291	0.9681**
	G	0.0018	-0.0022	-0.0003	-0.0032	0.0154	-0.0049	0.0012	**1.0077**	-0.0149	-0.0345	0.9662**
Biomass per plant	P	-0.0131	-0.0056	0.0002	0.0036	0.0079	-0.0005	0.0017	0.2926	**-0.0564**	0.0283	0.2585**
	G	-0.0166	-0.0074	-0.0001	0.0062	0.0098	-0.0005	0.0022	0.2410	**-0.0621**	0.0321	0.2047*
Harvest index (%)	P	0.0537	0.0031	-0.0006	-0.0054	0.0066	-0.0043	-0.0004	0.5832	0.0317	**-0.0503**	0.6174**
	G	0.0575	0.0040	-0.0007	-0.0079	0.0079	-0.0041	-0.0005	0.6194	0.0355	**-0.0561**	0.6549**

Phenotypic residual effect = 0.0578, Genotypic residual effect = 0.0560 ; P- Phenotypic level, G- Genotypic level ; Bold values - Direct effects, Normal Values - Indirect effects;
**** Significant at 1%, * Significant at 5 %**

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Research Note
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SELECTION CRITERION BASED ON TRAIT LINKAGES IN AFRICAN AND ASIAN PEARL MILLET [*Pennisetum glaucum* (L.) R. Br.] POPULATIONS TO ENHANCE PRODUCTIVITY

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Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is commonly grown in the arid and semi-arid regions of Africa and Asia. It serves as staple food for the people living in relatively dry tracts of the India and Sub-Sahelian Africa and an important source of fodder/ feed for livestock and poultry. It can be cultivated even in the poor infertile soils and drought prone environments, where no other cereal crop can survive. In India, currently pearl milletis cultivated on ~7.5 m ha area with grain production of 9.7 Mt with an average productivity of 1,305 kg ha^{-1}(www.indiastat.com). The ultimate aim in most plant breeding programs is the improvement in the productivity of grains as measured in terms of the yield per unit area. The possibilities of achieving this goal through genetic improvement have been elucidated by evolving high yielding hybrids and varieties of pearl millet in Asia and West Africa.

Pearl millet germplasm such as landraces, open pollinated varieties (OPVs) and populations exhibits a wide range of valuable genetic variability for agronomic traits, tolerance to biotic and abiotic stresses and are often well adapted to varying climatic condition. These landraces and OPVs are majorly cultivated in African countries where as Indian pearl millet cultivation is dominated by hybrids and an area of about 2 m ha is under OPVs and landraces. The existing wide variability in the pearl millet germplasm is less utilized in the breeding program (Yadav *et al.* 2009). Therefore, assessing the extent of variability for the economically important traits and identification of promising germplasm is essential to generate knowledge useful for efficient breeding programs. Recently, few studies have been carried out to assess variability among pearl millet germplasms of Asia (Yadav *et al.,* 2004; Yadav *et al.,* 2009; Jyothi Kumari *et al.,* 2016) and Africa (Bashir *et al*., 2014; Pucher *et al*., 2015; Sattler *et al*., 2017). They reported existence of wide variability among the germplasm for various yield-contributing traits. Nevertheless, until now, there is no increase in productivity (or in improvement in yield of OPVs) even though there is substantial increase in area and production in Africa (ICRISAT and ICARDA, 2012). This necessitates utilization of germplasms in current breeding programs by studying the relationship and effects of various yield-contributing traits on grain yield to derive proper selection criteria for enhancing productivity in pearl millet crop.

Correlation analyses relationship among the characters has great value in the evaluation of the most effective procedures for selection of superior genotypes. Positive association between major yield contributing characters would be desirable and it eases the selection process in breeding program. Correlation analyses provides relationship at phenotypic, genotypic and environment level. The genotypic correlation is the heritable association among the traits, and the environmental correlation is environmental deviations together with non-additive genetic deviations (Allard, 1960; Falconer and Mackay, 1996). However, Correlation measures only mutual association between traits and does not say anything about the cause and effect relationship (Roy, 2000). Hence, Path coefficient analysis is an important statistical tool that indicates which variables (causes) exert influence on other variables (effects). It measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects as well as specifies the relative importance of the characters (Dewey and Lu, 1959). In any breeding

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program where target trait is grain yield improvement for which direct selection is not effective, it becomes essential to measure the contribution of each of the component variables towards higher grain yield and to partition the correlation into components of direct and indirect effect. Therefore, the present study was conducted to determine trait association and direct and indirect effects of yield contributing traits on grain yield of pearl millet populations.

Forty-five pearl millet populations of Asian and African genetic backgrounds were evaluated in this study. The experiment was conducted during rainy season of 2015 at two locations, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (18°N, 78°E) and Regional Agricultural Research station (RARS), Palem (17°N, 78°E), Professor Jayashankar Telangana State Agricultural University (PJTSAU).

The experimental trial involving 45 populations (10 Asian origin and bred in Asia, 7 African origin and bred in Africa, and 28 African origin and bred in Asia) laid out in alpha-lattice design with three replications. In each replication, the size of the plot consisted of 6 rows with a length of 4 meters. The spacing between the rows and within the plants was maintained at 75 cm and 12-15 cm, respectively. A basal dose of 100 kg of di-ammonium phosphate (18% N and 46% P) was applied at the time of field preparation and 100 kg of urea (46% N) was applied as top dressing in two-split dose at the stage of three weeks and five weeks after sowing. Trials were regularly irrigated to avoid any moisture stress. All the recommended agronomic practices were followed for raising good crop.

Data collection was done for the grain yield and six yield component characters. The observations were taken on 20 random plants from each population for the traits like plant height (cm), number of productive tillers/plant, panicle length (cm), and panicle girth (cm). Other traits such as days to 50% flowering, 1000-grain weight (g) and grain yield (g) data were recorded on plot basis. Further, data of grain yield was converted to kg ha^{-1}.

Phenotypic and genotypic linear correlation coefficients were calculated for all the possible comparisons using the formula suggested by Falconer and Mackay (1996). The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu (1959). Data analysis was carried out using SAS v 9.4 software (SAS, Inc., 2017).

The genotypic and phenotypic correlation coefficients between all possible combinations of traits and the direct and indirect effects are presented in Tables 1 and 2.

Table 1. Analysis of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients for grain yield and yield component traits in pearl millet across locations

Trait	DFF	PHT	NPT	PL	PG	TGW	GY
DFF		0.86**	-0.57**	0.63**	0.19*	-0.29*	0.33**
PHT	0.72**		-0.61**	0.72**	0.22**	0.02	0.50**
NPT	-0.35**	-0.45**		-0.47**	-0.70**	-0.42**	-0.41**
PL	0.54**	0.68**	-0.30*		-0.05	0.00	0.23*
PG	0.13	0.18*	-0.45**	-0.05		0.65**	0.59**
TGW	-0.24*	-0.03	-0.16	0.00	0.43**		0.28*
GY	0.19*	0.38**	-0.22*	0.02	0.39**	0.18*	

*, **, Significance at 0.05, 0.01 levels of probability, respectively

DFF: Days to 50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight(g), GY-Grain yield (kg ha^{-1})

Table 2. Path coefficient analysis of grain yield [direct effects (diagonal) and indirect effects] with other yield component traits in pearl millet, across locations

Trait	DFF	PHT	NPT	PL	PG	TGW	GY
DFF	**-1.27**	1.28	-0.17	0.02	0.23	0.24	0.33**
PHT	-1.09	**1.49**	-0.19	0.03	0.28	-0.02	0.50**
NPT	0.72	-0.91	**0.31**	0.01	-0.88	0.34	-0.41**
PL	-0.80	1.07	-0.14	**0.16**	-0.06	0.00	0.23*
PG	-0.24	0.33	-0.22	-0.01	**1.25**	-0.53	0.59**
TGW	0.37	0.03	-0.13	0.01	0.81	**-0.81**	0.28*

*, **, Significance at 0.05, 0.01 levels of probability, respectively

DFF: Days to 50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight (g), GY-Grain yield (kg ha^{-1})

Phenotypic and genotypic correlation between grain yield and all of the component traits was significant and positive for all the traits except for number of productive tiller per plant for both phenotypic and genotypic level (Table 1). Highest significant positive correlation for grain yield was found with panicle girth (r = 0.59, P d" 0.01) followed by plant height (r = 0.50, P d" 0.01), days to 50% flowering (r = 0.33, P d" 0.01), 1000-grain weight (r = 0.27, P d" 0.01) and panicle length (r = 0.23, P d" 0.01). Whereas, number of productive tillers per plant had negative correlation with grain yield. However, high tillering and asynchrony of tillering is attributed to adaptation to drought stress during the vegetative growth phase rather than its positive association with grain yield under optimum environmental condition (Yadav and Rai, 2013). This indicated that grain yield increases with increase in panicle girth, plant height, bold seed size and late flowering. Previous studies by Kulkarni *et al*., (2000) Borkhataria *et al.,* (2005) and Yahaya *et al.,* (2015) also reported the strong correlation between grain yield with plant height, panicle girth, panicle length and 1000-grain weight. The correlation coefficient for most of the pairs of characters revealed the presence of strong positive genotypic association between yield and its component traits. In addition, genotypic correlation coefficients were higher than their respective phenotypic correlation coefficients for all the characters under study. This indicated strong inherent association between the different characters studied but the phenotypic values was lessened by the significant interaction of environment on the traits under study. Previous studies in pearl millet also reported high genotypic correlation than phenotypic correlation (Chaudry *et al.,* 2003, Atif *et al.,* 2012, Yahaya *et al.,* 2015 and Dehinwal *et al.,* 2017).

Days to 50% flowering had significant positive correlation with most of the traits except number of productive tillers per plant and 1000-grain weight. The plant height had high positive genotypic and phenotypic correlation with all yield component traits except with number of productive tillers/plant (Table1). It indicated that selection for plant height will be rewarding to improve the grain yield. The number of productive tillers/plant had highly significant negative genotypic and phenotypic correlations with all the component traits (Table 1). Panicle length exhibited highly significant positive correlation with days to 50% flowering (r = 0.63, P d" 0.01) and plant height (r = 0.72, P d" 0.01) while it had negative

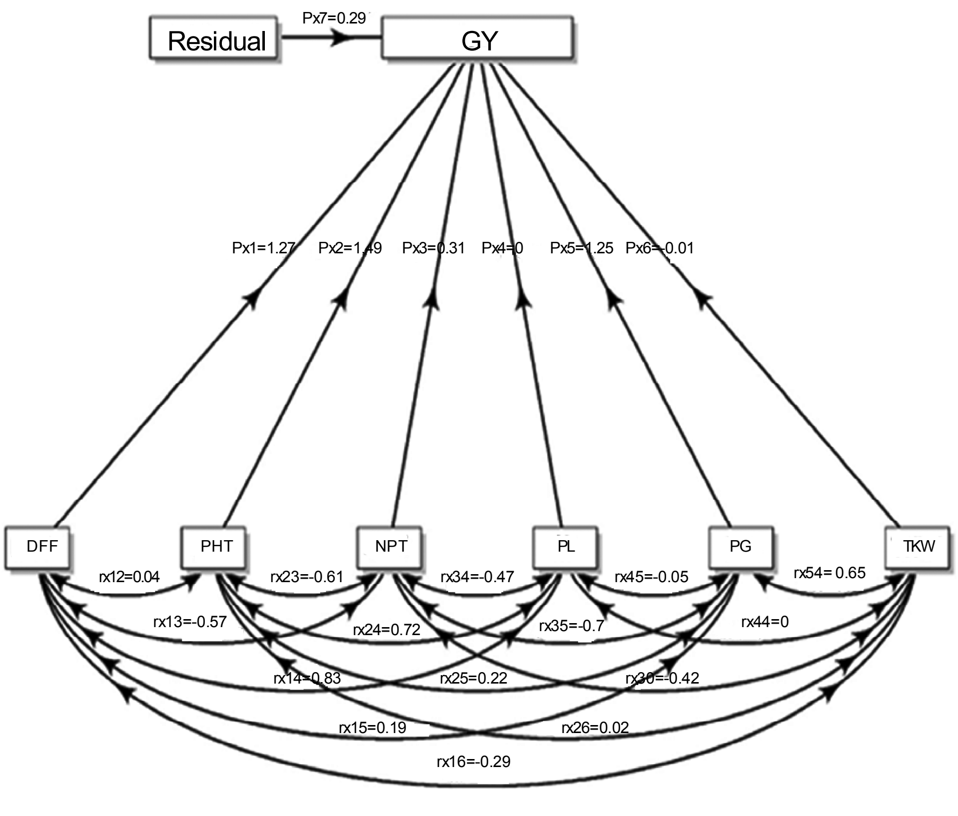

Fig.1: Path diagram for grain yield (kg ha^{-1}) and its component traits for pearl millet

[DFF: Days to50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight (g), GY-Grain yield (kg ha^{-1})]

correlation with rest of the traits. Panicle girth had significant but low positive correlation with days to 50% flowering and plant height. Thousand-grain weight has significant positive correlation with panicle girth (r = 0.65, P < 0.01) and it had no correlation with plant height and panicle length (Table 1).

Path coefficient used to study the cause and effect relationship, delineates the correlation coefficient into direct and indirect effect. Direct and indirect effects of all the characters are presented in Table 2 and Fig.1. Plant height had strong positive direct effect (1.49) on grain yield, followed by panicle girth (1.25) whereas number of productive tillers per plant (0.31) and panicle length (0.16) had low direct effects. On the other hand, grain yield had direct negative effect by days to 50% flowering (-1.27) and 1000-seed weight (-0.81). Residual effect was low (0.29) indicated that most of the yield contributing traits in pearl millet were considered in the present study. The high positive direct effects of plant height and panicle girth were in agreement with previous reports of Kumar *et al.,* (2014), Ezeaku *et al.,* (2015), Talwar *et al.,* (2017) and Dehinwal *et al.,* (2017).The relatively high positive indirect effects on grain yield was caused by days to 50% flowering via plant height (1.28) followed by panicle length via plant height (1.07) and1000-grain weight via panicle girth (0.81).This indicated that selection for days to 50% flowering and panicle length traits would contribute to high grain yield via plant height. Talwar *et al.,* (2017) and Unnikrishnan *et al.,*(2004) reported high positive indirect effect of these traits on grain yield. The highest negative indirect effects on grain yield was caused by plant height via days to 50% flowering (-1.09) followed by number of productive tillers/plant via plant height (-0.91).

The results indicated that days to 50% flowering, plant height, and panicle girth had high positive significant correlation and these traits had high direct effects with grain yield. In addition, plant height and panicle girth have high positive indirect effect each other on grain yield. This shows that selection based on plant height and panicle girth are more effective to improve grain yield. Panicle length also an important trait to be considered since it had positive direct effect and high indirect effect on grain yield via plant height. However, number of productive tillers had high direct effects it cannot be considered for selection since it had negative indirect effects via plant height and panicle girth as well as negative correlation with yield and its component traits. Hence, selection should be carried out based on plant height, panicle girth and days to 50% flowering to develop superior breeding material.

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