Groundnut improvement: use of genetic and genomic tools

Janila P
ICRISAT,
Patancheru, India
Hunger report of FAO, 2012

Improve food availability and incomes of the poor by enhancing their productive activities

Source: http://www.fao.org/infographics/pdf/FAO-infographic-SOFI-2012-en.pdf
Global groundnut area

- 24 m ha
- 36.5 m t production

- Oil
- Food uses
- Cash crop
- Nutritious
Groundnut research at ICRISAT

New improved varieties of groundnut are an important and cost effective solution
Out line

- Defining objectives
- Breeder’s tool kit
  1. Genetic variability
  2. Genetic nature and trait association
  3. Breeding methods
  4. Phenotyping tools
  5. Genomic tools
  6. Participatory breeding
- IMOD developmental pathway
- Challenges – nutrition & aflatoxin
- Summary
Groundnut breeding objectives ......

- Dynamic challenges of production and adaptation
- Preferences of farmers, traders, millers, processors and consumers
- Nutrition
- IMOD development pathway
- Gender
- Yield gap
Groundnut yield varies from 300 to 5600 Kg ha\textsuperscript{-1} across the growing regions of the world.
Plugging the yield gap is important

New improved genotypes

ICM technologies, inputs, mechanization etc.

Technology delivery
Tool kit

Janila et al (2013) Frontiers in Plant Science.
(1) Genetic variability

- Available variability
  - cultivated species (⊙)
  - wild species (⊙)

- Induced variability
- Interspecific hybridization
- Gene banks and breeding programs

Single hybridization event followed by chromosome doubling

Crossing barriers - ploidy differences
(2a) Trait genetics – hold the torch

Genetic nature of LLS resistance

- Nuclear and maternal effects
- Field measured traits had high heritability compared to lab measured traits for resistance
- Early-generation selection may not be rewarding

Janila et al (2013). Euphytica. (doi:10.1007/s10681-013-0881-7)
(2b) Trait associations

Pod yield - mature pods & kernels
shelling outturn
100-seed mass
primary and secondary branches
harvest index

Water-use-efficiency (WUE) -
SPAD chlorophyll meter reading (SCMR)
Specific leaf area (SLA)
(3a) Breeding methods

- Introduction and Mass selection
  - JL 24 is selection from EC 94943, introduced from Taiwan (Patil et al. 1980)

- Mutations
  - TMV 10, TG 1, TG 3, TG 17, TG 38, Somnath, G 201, BG 1, BG 2, MH 2
  - 15% of new groundnut varieties (Qui et al., 1998).
(3b) Breeding methods

Hybridization and selection
Pedigree
Bulk-pedigree
Single seed descent method
Backcross
(3c) Untiring efforts....

Groundnut hybridization block
(4a) Phenotyping tools – foliar fungal diseases

Field screening technique

Detached leaf technique

Disease score on 1-9 scale, 1 = no disease, and 9 = 81-100% foliage destroyed (Subrahmanyan et al 1983)
(4b) Phenotyping tools – drought tolerance

- Empirical approach
- Trait based approach

Recording of SCMR in progress

Screening of high oil lines under water stress during 2011/12 postrainy season at ICRISAT, Patancheru

Janila and Nigam (2013) Springer Pub., USA (in press)
(4c) Robust phenotyping tools

NIRS (near infrared reflectance spectroscopy) – robust, non-destructive and rapid method of estimation for oil, protein and fatty acid content
(5a) Genomic tools

- NemaTAM (Simpson et al., 2003)
- Tifguard High O/L (Chu et al., 2011)

- The uptake in developed countries is contrasting with that in developing countries such as, India and African countries.

- New emerging tools – happening at a fast pace
(5b) MABC for rust resistance

Introgression lines, ICGV 91114 (left pink tag) and GPBD 4 (right pink tag) in rust screening nursery at 90 DAS (2012 rainy season ICRISAT Patancheru)
(5b) Rust score of MABC derived lines

| Parents    | Rust score at 75 DAP * | Rust score at 90 DAP | Rust score at harvest |
|------------|------------------------|----------------------|-----------------------|
| GPBD 4     | 1                      | 2                    | 3                     |
| ICGV 91114 | 3                      | 5                    | 9                     |
| JL 24      | 3                      | 5                    | 9                     |
| TAG 24     | 2                      | 5                    | 9                     |

| Cross                  | Number of lines evaluated * | Lines with mean disease score of 2 * |
|------------------------|-----------------------------|--------------------------------------|
| ICGV 91114 x GPBD 4    | 57                          | 25                                   |
| JL 24 x GPBD 4         | 69                          | 23                                   |
| TAG 24 x GPBD 4        | 103                         | 29                                   |

Replicated disease screening nursery during 2012 rainy season at ICRISAT, Patancheru; * mean of two replications
(5c) MABC in progress

- High O/L ratio for oil quality
- Gene pyramiding for rust and late leaf spot resistance
(6) Participatory breeding

Amalgamation of Past and present competencies to find solutions of the future
IMOD developmental pathway

- Innovations
- Higher-value agriculture
- Market-oriented
- Re-invest gains: the engine of growth
- Resilience
- Social assistance
- Access to inputs and market opportunities
- Manage risks
- Harness markets
- From food deficit to surplus
- Subsistence
- Innovate. Grow. Prosper.
“s for commercialization of high oil groundnut varieties

Market?

Seed viability?

Seeding growth of seed stored for one year under room temperature conducted at ICRISAT, Patancheru (2011-2012)

No association between seed viability with kernel oil content \( r = -0.22 \)

- Narasimham et al (1985). Journal Article No. 21 of ICRISAT.
- Janila et al (2013) (under preparation)
Farmers oriented to markets

Dual purpose genotypes

- Protein (8-15%)
- Minerals (9-17%)
- Genetic variability
- No inverse relation

ILRI study - use of ICGV 91114 haulm fodder enhanced milk yield by 11%

- Nigam SN, Blummel M. Animal Nutrition and Feed Technology 2010;10S:39-48.
- Prasad VL et al (2006). International Conference on social science perspectives in agricultural Research and development, Feb 15-18, 2006, New Delhi, India.
Addressing nutrition …..

Groundnut with maize grown for home consumption or for local market as fresh pods (Nawada district, Bihar, 2012)

Aflatoxin contamination
Summary
138 ICRISAT bred groundnut varieties were released in 36 countries of Asia and Africa.

Conventional breeding procedures with phenotyping tools have contributed to release of several improved varieties of groundnut world over.

A farmer showing ICGV 91114 grown in Anantapur (India), the largest groundnut growing district of the world.
New improved varieties are an important part of the solution, but ..

- ICM practices
- Seed systems
- Partnerships
- Policies
- Input delivery
- Mechanization
- Credit facilities
- Institutions

The former Chief Minister of Andhra Pradesh, late Dr YS Rajasekhara Reddy hands over the ICGV 91114 seeds to Anantapur farmers on 1 June 2006. He is flanked by Director General Dar (on his right), and Mr N Raghuveera Reddy, Agriculture Minister
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