Forage (i.e. fodder, forage, feed) quality improvement

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CGIAR

ILRI
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Rationale

- Feed cost the greater part of input costs and feed cost are rising relative to farm gate process of animal source food
- Feed at the interface of positive and negative effects of livestock
- Increasing feed quality could result in reduction of overall feed needs
- Feed production, transaction and processing results in multiple off-farm income and employment opportunities

ILRI approaches to forage improvement

- Targeting, prioritizing, ex-ante assessments, demand, opportunities for leveraging partnerships
- Focus on non-food competing feed stuffs (directly or indirectly)
- Adopting value chain approaches, private sector involvements
- Recognizing the primacy of economics over biology; also feed is ONLY one possible entry point

Targeting, prioritizing, ex-ante assessments, opportunities for leveraging partnerships

Feed resource in India in 2012	Contribution to overall feed resources (%)
Greens from CRP, forests, grazing	8.0
Planted forages	15.1
Crop residues	70.6
Concentrates	6.3
Deficit: feed availability versus feed requirement (%)	
Dry matter (i.e. crop residue quantity)	-6
Digestible crude protein	-61
Total digestible nutrients	-50

Multi-dimensional crop improvement: concomitant improvement of food and fodder traits

- Infrastructure, logistics
- Exploit existing genetic/cultivar dependent variations
- Targeted genetic enhancement (conventional and molecular breeding)


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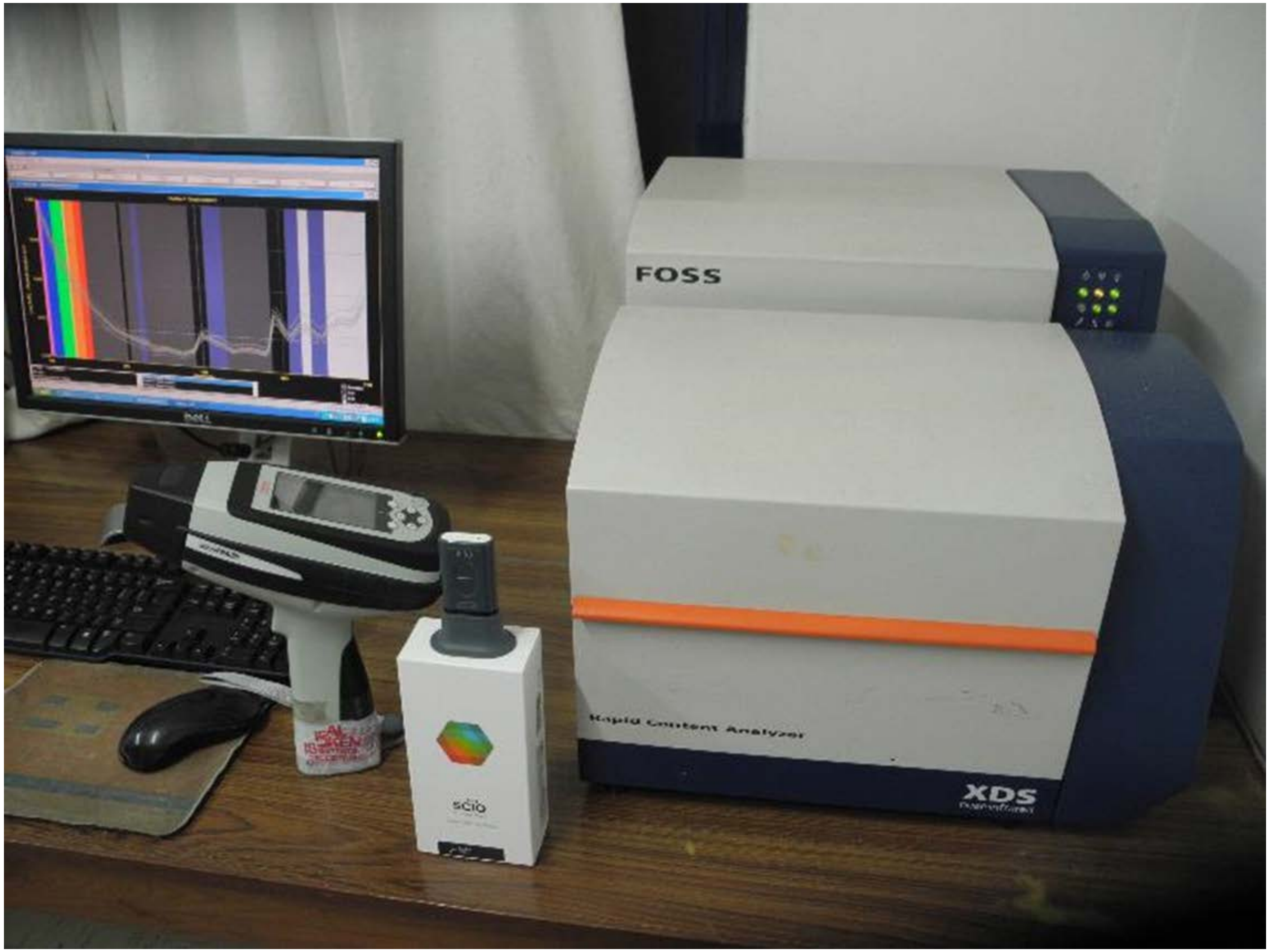
Livestock Nutritional Facilities at ILRI - ICRISAT
ICRISAT
Suitable model animal
NIRS Prediction Global Platform
Validation of laboratory traits
Validation of laboratory traits
Microbial inoculum
Combined gas volume & substrate degradability measurements
SCFA – GAS - COMPLEX
GAS
SCFA
OMTDR
Calibration of NIRS with Validated laboratory traits

ILRI NIRS Hubs in South Asia and East and West Africa: very wide range of NIRS equations



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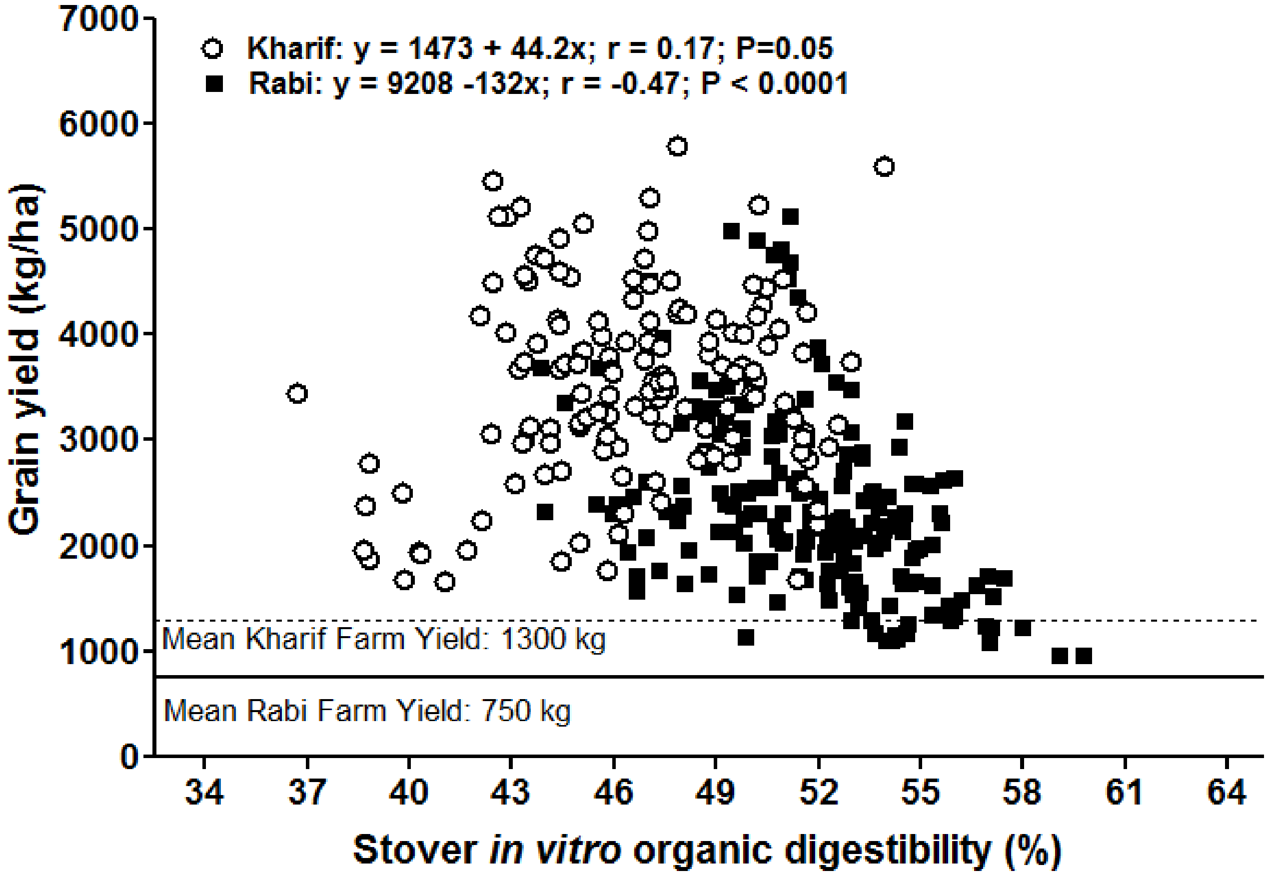
Exploit existing cultivar-dependent variations in food-feed trait



Stover fodder trait analysis in new sorghum cultivar release testing in India 2002 to 2008

(Blümmel et al. 2010)

Exploit existing cultivar-dependent variation in food-feed trait: tested and validated

- Sorghum (South Asia, East/South/West Africa
- Pearl millet (South Asia)
- Rice (South Asia, West Africa)
- Maize (South Asia, East Africa)
- Groundnut (South Asia, West Africa)
- Cowpea (West Africa)
- Pigeon pea (South Asia, East Africa)
- Chickpea (South Asia)
- Wheat (South Asia, odd one out, relatively little variations in fodder traits)

NOTE: SCALING A CHALLENGE IN OPVs PARTICULARLY LEGUMES

Targeted genetic enhancement towards food-feed traits

Conventional breeding

- Recurrent selection
- Hybridization

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Molecular breeding

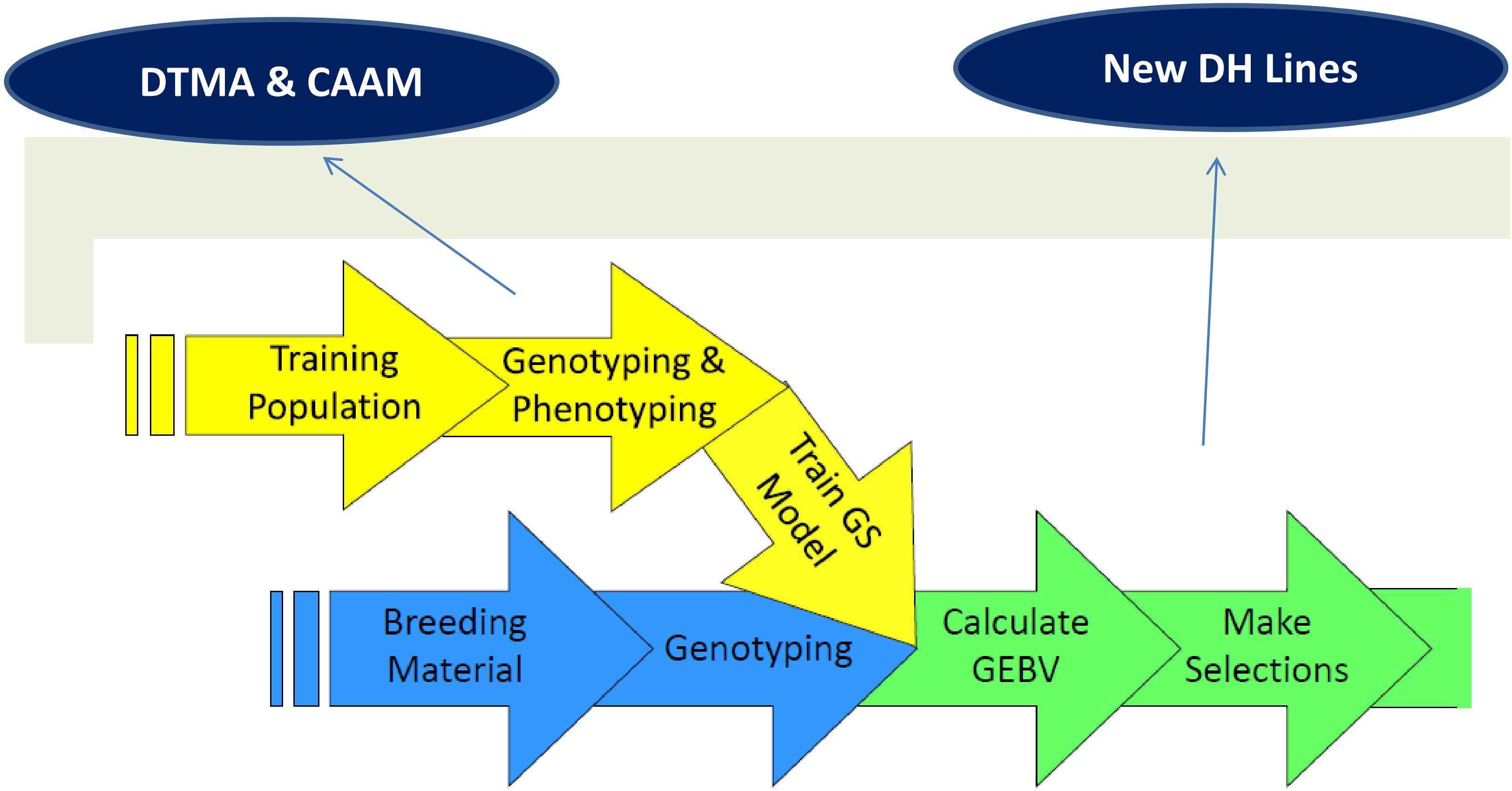
-QTL, stay green introgressions
- Association mapping, genomic selections

Original and experimental pearl millet stover ICMV 221 tested with sheep: 2 recurrent selection cycles

Selection criterion	Digestible Intake	Grain yield
Original ICMV 221	29.2 g/kg $LW^{.75}$ /d	3 110 kg/ha
Exp: Dual Purpose 221	31.5 "	3 250 "
Exp: Grain 221	27.5 "	3 110 "
Significance (P <)	0.0001	ns

Bidinger et al. 2009

Dual Purpose Maize: Genomic Selection



(Babu et al. 2016)

Dual Purpose Maize: Genomic Predictions

ID	IVOMD - Predicted	IVOMD-Observed
DH_9_157	High IVOMD and ME	57.1
DH_3_33	High IVOMD and ME	56.7
DH_3_63	High IVOMD and ME	55.8
DH_9_15	High IVOMD and ME	55.7
DH_8_4	High IVOMD and ME	55.6
DH_3_149	High IVOMD and ME	55.5
DH_3_24	High IVOMD and ME	55.4
DH_6_1	Low IVOMD and ME	55.4
DH_3_10	High IVOMD and ME	55.0
DH_3_21	High IVOMD and ME	54.9
DH_3_138	High IVOMD and ME	54.6
DH_3_35	High IVOMD and ME	54.5
DH_3_61	High ME	54.4
DH_3_83	High IVOMD and ME	54.1
DH_9_165	High IVOMD	53.6
DH_9_134	High IVOMD	53.6
DH_9_153	High IVOMD and ME	53.5
DH_3_47	High IVOMD and ME	53.4
DH_3_62	High IVOMD and ME	53.4
DH_3_87	High IVOMD and ME	53.4
DH_3_82	High IVOMD	53.3

HTMA - GS	Pred. Accuracy
IVOMD	0.44
ME	0.45

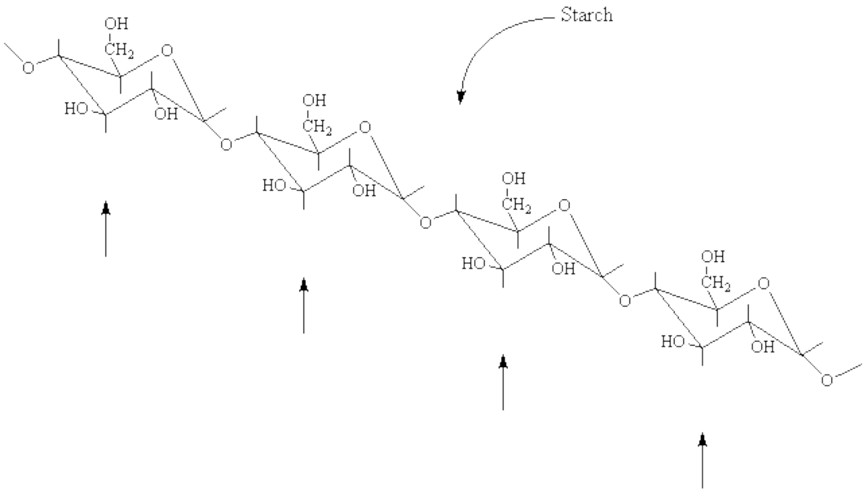
(Babu et al.2016)

Targeted genetic enhancement towards food-feed traits

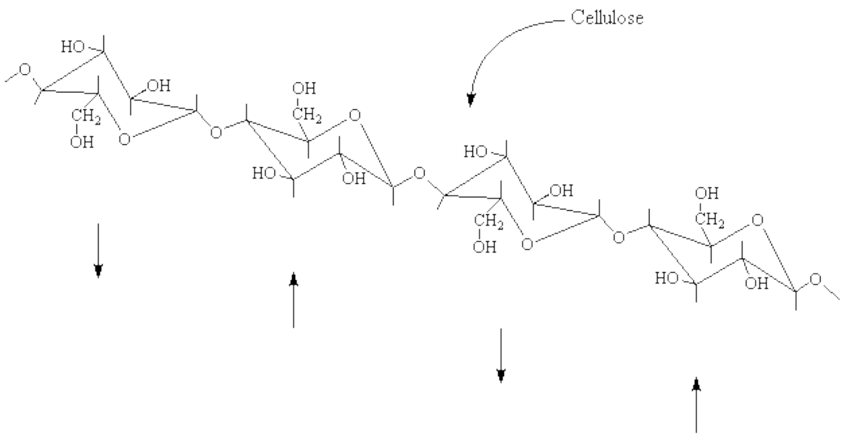
- Crops applied to: sorghum and pearl millet, maize, groundnut
- Forages applied to: Napier, short duration, water-use efficient single and multi-sorghum and pearl millet forage cultivars
- Promising results in maize, by conventional and molecular breeding)
- Potentially high impact, multi-traits can be targeted

Leveraging spin-off technologies from 2nd generation for deconstructing ligno-cellulosic biomass

- 10 – 50 Billion tons biomass annually
- Billions of $ investment to leverage
- Dissolve boundaries between food-feed-fodder
- Potential game changer technology
- Ongoing pilot studies between ILRI and Michigan Biotechnology Institute (MBI) on rice straw, wheat straw, maize stover, sorghum stover, pearl millet stover



In starch, all the glucose repeat units are oriented in the same direction. But in cellulose, every other repeat unit is rotated 180 degrees around the axis of the backbone, relative to the previous repeat unit.



Leveraging spin-off technologies from 2nd generation for deconstructing ligno-cellulosic biomass

Summary of effects of steam, ammonia fiber expansion and 2CC treatment on *in vitro* gas production (GP) and true *in vitro* digestibility[-1] after 48 h of incubation.
U = untreated; T = Treated

Spin-off technology	n	In vitro GP after 48 h (ml/200 mg)		True IVOMD after 48 h (%)	
		U	T	U	T
Steam Treatment	4	48.6	53.6	62.9	71.8
AFEX Treatment	10	42.9	51.5	65.1	84.4
2CC Treatment	11	39.7	66.7	55.9	94.1

[-1] The average difference between true and apparent IVOMD is about 12.9 percentage units (van Soest, 94). Increments in digestibility are similar independent of expression as apparent or true digestibility.

(Blummel et al., 2018)

Adopting value chain approaches, private sector involvements

Ingredients	%
Sorghum stover	50
Bran/husks/hulls	18
Oilcakes	18
Molasses	8
Grains	4
Minerals, vitamins, urea	2

Courtesy: Miracle Fodder and Feeds PVT LTD

Comparisons of feed blocks based on lower (47%) and higher (52%) digestible sorghum stover and tested with commercial dairy buffalo farmer in India

	Block Premium	Block Low
CP	17.2 %	17.1%
ME (MJ/kg)	8.46 MJ/kg	7.37 MJ/kg
DMI	19.7 kg/d	18.0 kg/d
DMI per kg LW	3.8 %	3.6 %
Milk Potential*	15.5 kg/d	9.9 kg/d

* 21 and 14 kg/d in crossbred cattle

Modified from Anandan et al. (2009a)

Feed processing solutions are context specific: supplementation and processing of sweet sorghum bagasse and response in sheep

				
DMI (g/kg LW)	52.5 [a]	55.6 [a]	42.1 [b]	41.5 [b]
ADG (g / d)	132.7 [a]	130.4 [a]	89.5 [b]	81.3 [b]
Processing ($/t)	5.9	7.0	5.2	1.7
Transport ($/t/100km)	6.6	5.8	5.2	13.5

Anandan et al. (2009b)

ILRI approaches to forage improvement : Summary & Outlook

- Multi-dimensional crop improvement close to mainstreamed ("Full Purpose Crop" Concept)

- ILRI supporting public and private and national and international crop improvement in a hub function

- Upgrading of and value addition to basal diets/non food competing feed stuffs

- Focus more on off farm improvement of feed resources through provision of affordable quality feed (land, water and labor constraints of small holders) *better lives through livestock*

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