## Objectives

- Development of high yielding, medium flowering and foliar disease resistant single cut forage and dual purpose varieties with high nutritional quality and seed yield.
- Development of high yielding, early flowering, sweet and highly nutritious multi cut forage sorghum varieties and cytoplasmic male sterility based multi cut forage sorghum hybrids between sorghum (CMS lines) and sudan grass pollinators.
- Basic genetic studies on inheritance of yield and nutritional quality parameters viz. protein, dry matter digestibility, sweetness, juiciness and anti-nutritional factors such as HCN, tannin and fiber (components of NDF and ADF like celluloses, hemicelluloses, lignin etc.)
- Improvement in nutritional quality of potentially high yielding genotypes by using appropriate breeding methodology based on information generated from basic genetic studies.
- Development of special types (red grain, BMR and high biomass) sorghum for industrial use
- Development of three way cross hybrids with red/white grain to address problem of F₁ seed yield and market/consumer preference
- Popularization of newly developed varieties and hybrids of forage sorghum among farmers through organizing Front Line Demonstrations.
- Promoting Public-Private Partnership (PPP) to commercialize seed production and to disseminate hybrid seeds of new and improved forage sorghum hybrids, to the target farmers/dairymen throughout the country.

## A. Sorghum Breeding

### 1. Significant Achievements:

Being the only Agriculture University in the state of Uttar Pradesh at that time and keeping in view of the importance of sorghum as one of the major fodder crops in the state, the work on sorghum improvement was initiated at Pantnagar in the year 1967.Received from various national and international agencies, a collection of more than 2500 germplasm lines (mostly IS numbers) was evaluated for fodder yield and nutritional quality parameters. Selected on the basis of 2-3 years of evaluation, the lines viz. IS 4776, IS 6953, IS 9722, IS 7002, IS 3555, IS 6090, IS 8087, IS 607 and IS 4777 which were found promising in station trials were incorporated for evaluation in All India Coordinated Trials. Later, by including the above selected lines alongwith released and popular sorghum varieties of other states viz. Vidisha 60-1, (Madhya Pradesh), JS 73/53 (Haryana), SL 44 (Punjab), MP Chari (Madhya Pradesh) and sweet sorghum variety Rio (released in India through direct introduction), in the crossing block, the varietal development programme, based on inter-varietal crossing through hand emasculation and pollination, was also initiated in 1970. Identified donors for multiple traits like low HCN content, high digestibility and shoot fly resistance (IS 4776), high TSS (total soluble solids) and juiciness of stem (Rio, Leoti, IS 607), fast growth and regeneration (IS 6953), high forage yield (Vidisha 60-1) and good grain quality (CS 3541) were exhaustively used in the hybridization programme to generate variable breeding material for selection.

Considering the quantum and significance of research work done on forage sorghum improvement
and large number of entries contributed in the All India Coordinated Trials, Pantnagar was given the status of one of the Coordinating Centers of All India Coordinated Sorghum Improvement Project (ICAR) in 1976.

Development of forage sorghum varieties and Single cross hybrids

In view of the great popularity of multicut forage sorghum among the farmers and dairymen, the on-going research efforts are mainly focused at the development of high yielding multicut varieties and hybrids with high resistance to foliar diseases and improved nutritional quality. Improvement in conventional forage varieties of multicut types for nutritional quality, disease resistance and seed production ability is in progress through combined research efforts in the disciplines of Breeding and Genetics and Plant Pathology. Till date Pantnagar centre working on the mandate of developing high yielding, early flowering, disease resistant and improved nutritional quality varieties/hybrids have developed and released twelve (12) varieties of forage sorghum viz. UP Chari 1, UP Chari 2, Pant Chari 3, Pant Chari 4, Pant Chari 5, Pant Chari 6, Pant Chari 7, Pant Chari 8, Pant Chari 9, Pant Chari 10, Pant Chari 11 and CSV 35F and three hybrids viz. CSH 20 MF, CSH 24 MF and CSH 40F, brief details of which are given in the following table. New single cross hybrids and varieties of single cut and multicut types are regularly contributed in AICSIP and State Evaluation Trials.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Variety/ Hybrid</th>
<th>Year of release (releasing agency)</th>
<th>Single cut/ Multicut (2-3 cuttings)</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>UP Chari 1</td>
<td>1979 (SVRC/CVRC)</td>
<td>Single cut</td>
<td>High fodder yield, low HCN content, highly juicy &amp; resistant to stem borer and shoot fly</td>
</tr>
<tr>
<td>2.</td>
<td>UP Chari 2</td>
<td>1983 (CVRC)</td>
<td>Single cut</td>
<td>High fodder yield, high protein and digestibility, tolerant to foliar diseases</td>
</tr>
<tr>
<td>3.</td>
<td>Pant Chari 3</td>
<td>1989 (SVRC)</td>
<td>Single cut</td>
<td>High fodder yield, high protein and digestibility, tolerant to foliar diseases,</td>
</tr>
<tr>
<td>4.</td>
<td>Pant Chari 4</td>
<td>1994(SVRC)</td>
<td>Single cut</td>
<td>High fodder yield, high protein and digestibility very juicy and sweet stem</td>
</tr>
<tr>
<td>5.</td>
<td>Pant Chari 5</td>
<td>1999 (CVRC)</td>
<td>Single cut</td>
<td>High green fodder yield (550q/ha), high protein and digestibility, very juicy and sweet stem, resistant to foliar diseases with stay green character. Good grain quality and yield with pearly white bold grain.</td>
</tr>
<tr>
<td>6.</td>
<td>Pant Chari 6</td>
<td>2004(SVRC)</td>
<td>Multicut</td>
<td>High green fodder yield (700-800 q/ha) very low HCN content, high protein &amp; dry matter digestibility</td>
</tr>
<tr>
<td>7.</td>
<td>CSH 20 MF (Hybrid)</td>
<td>2005 (CVRC)</td>
<td>Multicut</td>
<td>High fodder yield (800-950 q/ha green fodder), very low HCN content, high protein &amp; dry matter digestibility with resistance to foliar diseases.</td>
</tr>
<tr>
<td>8.</td>
<td>CSH 24 MF(Hybrid)</td>
<td>2009 (CVRC)</td>
<td>Multicut</td>
<td>High green fodder yield (800-950 q/ha) very low HCN content, high protein &amp; dry matter digestibility, resistance to foliar diseases.</td>
</tr>
<tr>
<td>9.</td>
<td>Pant Chari 7</td>
<td>2010(SVRC)</td>
<td>Single cut</td>
<td>High fodder yield (550-650 q/ha green and 225-275 q/ha dry) high protein content (7.70%), high digestibility (56.90%) Resistant to major foliar diseases.</td>
</tr>
</tbody>
</table>
Development of three way cross and red grain hybrids

To address the problem of poor seed yielding ability of conventional CMS lines being used in single cross hybrid development of forage sorghum, work is also in progress to develop three way cross and red grain hybrids. Two three way cross hybrids viz. SPH 1807 (UTMCH 1315-multicut) and SPH 1822 (UTFSH 3- single cut) are in advanced stage of testing in AICRP Trials.

Identification of best combiners for forage yield and quality

Best combining CMS lines viz. 2219A, ICSA 467, 11A, 32A, 104A, ICSA 469, ICSA 693 and ICSA 351 alongwith single cut restorer/pollinator Pant Chari 5 and multicut restorer/pollinator Pant Chari 6, SSG 59-3 and SGL 87 have been identified.

Pre breeding programme

A core collection of 400-450 diverse germplasm including sorghum, forage sorghum, sudan grass and several wild type sorghums is being maintained and utilized under pre-breeding programme. New crosses (F₁s), single plant progenies and progeny bulks of different crosses of different generations from F₂ to F₇ onwards are being planted for rigorous evaluation and single plant/bulk selections through within and between progeny rows/progeny bulks selection for desirable fodder traits viz. multicut/tillering, single cut/dual purpose, sweetness/juiciness of stem, brown midrib traits, foliar disease resistant, earliness and colour (red/brown/yellow) grain every year. During last two Kharif seasons (2017 and 2018) 40 new inter varietal F₁ crosses were made. Approximately 1000 single plant progenies and 100 progeny bulks of 140 crosses of different generations from F₂ to F₇ onwards, have been planted for rigorous evaluation and single plant/bulk selections through within and between progeny rows/progeny and bulks selection for desirable fodder traits viz. multicut/tillering, single cut/dual purpose, sweetness/juiciness of stem, brown midrib traits, foliar disease resistant and earliness etc.

B and R line development/ improvement programme

Beside conventional pre-breeding approach of inter-varietal crossing and selection in segregating generation, for CMS based hybrid development programme a collection of 67 pairs of A/B lines (A₁,
A₂ and A₃) is being maintained and utilized. Beside for development of new CMS lines a separate B line improvement development programme for disease resistance, panicle size/ seed yielding ability, red seed colour and earliness is also in progress. Single plant progenies of 12 B×B crosses have been advanced to further generations. Under R line/donor/varietal development programme, 62 multicut high tillering types as restorers, 19 sweet and juicy types, 77 disease resistant stay green types and 22 stable brown midrib types, as donors have been identified during last six to seven years. Twenty elite lines of multicut forage sorghum and twenty nine elite of single cut forage sorghum based on their performance in station trials have been identified for multi-location testing yield and quality evaluation trials at State and National level.

Identification of donors for various traits

Potential donors for high protein, high TSS, low HCN, disease and insect resistance, tillering and regeneration and special traits (BMR/coloured grain) have been identified and being used in the hybridization programme.

Diversification of cytoplasm source

Diversified cytoplasm (other than A₁ type Milo cytoplasm) for multi cut and single cut forage sorghum hybrid development is also in progress. Several collections of A₂, A₃ and A₄ cytoplasmic male sterile lines have been tested for their general combining ability with potential multicut type pollinator parents. The experimental hybrids based on alternate cytoplasm viz. 11 A₂ × Pant Chari 6 and 32 A₃ × Pant Chari 6 have been tested in the AICSIP multi location trials and the hybrids based on 11A₁ has been found to be promising for multicut and as well as single cut forage sorghum hybrids.

Sweet sorghum and high biomass sorghum for second generation bio fuel

Several sorghum genotypes with high sugar
content (high TSS) and high biomass production are available with the project which may be good choice as source of second generation biofuel. Avenues are also available to develop high sugared multi cut varieties and hybrids by using sweet stemmed genotypes in the breeding programme to improve CMS lines and sudan grass type pollinators. Advanced elite lines developed with BMR trait at the centre may also be explored for their use as source for second generation biofuel.

**Fodder Quality Improvement and use of BMR trait**

So far as nutritional quality is concerned, sorghum has highly palatable and digestible fodder with an average of 7.5-9.0 per cent crude protein and 48-55 per cent of dry matter digestibility. Furthermore, low HCN content is very important requisite for forage sorghum in general and for multi cut forage sorghum in particular, because it is to be fed before flowering and often face hot and dry weather before onset of monsoon. Therefore, besides improving the intake characteristics, elimination of toxic substances is another most important aspect of forage sorghum improvement programme. Brown Midrib (BMR) and coloured grain sorghum and three-way cross of forage sorghum hybrids are the prospects on which lot of opportunities are available to put concerted efforts in the coming years. Progenies of crosses between BMR (brown midrib) × GMR (green midrib) genotypes having the tan plants with brown midrib, less disease and other fodder quality attributes have been selected in advanced generations and some of the best elite lines have been evaluated for protein, fiber content and IVDMD per cent. Eight best BMR lines identified after evaluation will be registered under germplasm registration as potential donors for unique trait.

**Registration of varieties/hybrids under PPV & FR Act**

- Forage sorghum varieties Pant Chari 4, Pant Chari 5 and Pant Chari 6 and forage sorghum hybrids CSH 20 MF and CSH 24 MF have been registered with Protection of Plant Varieties and Farmers’ Rights (PPV & FR) Authority, New Delhi, as Extant Notified Varieties.

**Licensing for seed production through Public – Private Partnership**

Several MOUs are in operations between IIMR, Hyderabad and private seed companies of Andhra Pradesh, Karnataka and Maharashtra for production of large quantity of hybrid seed of multicut forage sorghum hybrids CSH 24 MF developed by this centre. The CSH 24MF has become very popular and occupies large area for fodder production.

**Nucleus and Breeder seed production**

Sufficient quantity of nucleus seed is being produced to meet the demand for breeder seed production against indents of Department of Agriculture and Cooperation (DAC). Appropriate quantity of breeder seed of forage sorghum varieties (Pant Chari 5, Pant Chari 6) and parental lines (ICSA 467/ICSB 467 and 2219A/B) is being produced and supplied to the indenting agencies by the Breeder Seed Production Centre of the University.

**Front Line Demonstrations**

Sorghum is the major fodder crop of *Kharif* season in the state of Uttarakhand where dairy industry is very well developed, especially in the whole area in districts of Udham Singh Nagar, Haridwar and Dehradun and plain areas of Nainital and Champawat districts. The local cultivars of sorghum being used by the farmers and dairyman for fodder production, besides having poor fodder yield, has high incidence of foliar and stem diseases, thereby hampering the nutritive value of the fodder and ultimately reducing milk production.

Seeds of improved varieties/hybrids of forage sorghum viz. Pant Chari 5, Pant Chari 6, CSV 30F, CSH 20MF, CSH 24MF and other promising hybrids are given to the farmers for conduction of FLDs. The feedback obtained from the farmers regarding improved cattle health and increased milk production as result of feeding of improved varieties, was very encouraging. The results on FLDs during last 5-7 years have shown fodder yield superiority of 55-80% along with greater
net monetary returns for Improved Practice (IP) with
use of improved varieties and cultural practice in
comparison to Farmers’ Practice (FP) with use of local
cultivars.

**Strategic Services**

Owing to leading centre for forage sorghum
research in the country and favourable climate for
character expression, Pantnagar is designated as
notified centre for testing of Distinctiveness,
Uniformity and Stability (DUS) for registration of
forage type varieties/hybrids under PPV & FR Act.
All the facilities required for DUS Testing such as
net-wire fenced DUS Test field, field laboratory
and digitalized database of DUS characteristics in
sorghum have been developed at the Centre. A
reference collection of sixty genotypes including
extant notified varieties and hybrids, local varieties,
example varieties and parental lines of forage and
dual purpose hybrids was characterized and the
data base for DUS characteristics of all the
genotypes of reference collection has been
developed at the centre and also submitted to the
PPV & FR Authority.

2. Research Publications:

- Chawla HS and Shrotria PK 1981. Effect of
  natural anthracnose infestation on protein
  content of sorghum leaves. *Sorghum

- Shrotria PK, Singh Rameshwar and Agarwal
  VK 1986. Screening of sorghum germplasm for
  resistance to grain mold. *Sorghum

- Sinha AP, Singh Rameshwar and Shrotria PK
  1986. Screening of breeder’s material in
  advance varietal trials for resistance to sorghum
  anthracnose, zonate leaf spot and grain moulds.

- Kataria SK, Singh Rameshwar, Shrotria PK and
  Bhatnagar S 1989. Gene action for tannin in
  grains of sorghum [*Sorghum bicolor (L.)
  Moench.*]. *Nat. Acad. Science Letters*. 12 (9):
  293-294.

- Shrotria PK, Singh Rameshwar and Agarwal VK
  1989. Evaluation techniques of sorghum genotypes
  for grain mold resistance. *Bangladesh Journal

- Kumar Rajendra, Singh R and Shrotria PK 1990.
  Correlation and path coefficient analysis for yield
  and other characters in grain sorghum [*Sorghum
  bicolor (L.) Moench.*]. *Forage Research*. 16
  (1):6-12.

- Kataria SK, Singh Rameshwar and Shrotria PK
  1990. Inheritance of resistance to grain mold
  fungi in three sorghum (*Sorghum bicolor*)
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- Kataria SK, Singh R, Agarwal BL, Shrotria PK
  and Bhatnagar S 1991. Combining ability
  analysis for resistance to grain mold in sorghum
  (*Sorghum bicolor*). *Proc. Nat. Acad. Sci*.
  61 (B), I: 127-130.

- Singh Rameshwar, Shrotria PK and Singh Vikram
  1992. Feed and forage sorghum breeding research.
  *In: Silver Jubilee Publication. Plant Breeding
  Symposium*. (1992). Crop Breeding in India-
  Current Status and Future Strategy 113-122. Held
  at Hill Campus of G.B.P.U.A. & T., Ranichauri,
  from November 2-4, 1992.

- Shrotria PK, Singh CP, Singh KN and Pandey
  *Green Gold Plus (GGP)* on grain sorghum

- Singh Rameshwar and Shrotria PK 1994. Pre-
  harvest quality maintenance in seed production.

  Heterosis and correlation in sorghum sudan
  grass interspecific crosses. *J. Maharashtra

- Desai SA, Shrotria PK and Singh Rameshwar
  1999. Variability and heterosis for yield and its...
Released Varieties & Hybrids of Forage Sorghum


• Singh RK and Shrotria PK 2008. Combining ability analysis for forage yield and its components in forage sorghum (Sorghum bicolor (L.) Moench) Forage Research. 34 (2) 79-82.


• Singh Shivji, Dwivedi VK, Shrotria PK and


- Pankaj Kumar and P.K. Shrotria (2016). Combining ability and heterosis studies for yield and component traits in forage sorghum (Sorghum bicolor (L.) Moench)” Green Farming Vol. 7(1),01-07.


- Pankaj Kumar, Girish Chandra and Shivji Singh (2015). Heterosis for quality and resistance traits in forage sorghum [Sorghum bicolor (L.) Moench]. Elixir Agriculture 81; 31830-31834.

- Pankaj Kumar, P.K. Shrotria, Girish Chandra and


**Popular Articles**


**3. Thesis Research:**

submitted for Ph. D. to GBPUAT under supervision of Dr. Rameshwar Singh.


19. Priyamvada Chauhan. 2016. Studies on molecular diversity, heterosis, combining ability and seed vigor
in sorghum [Sorghum bicolor (L.) Moench] submitted for Ph.D. to GBPUAT under supervision of Dr. P. K. Pandey.


4. Awards:

Based on the review of the work done on the aspects of variety release, publications, breeder and nucleus seed production, proper conduction of experiments, quality of data reported, basic and strategic research, contribution of entries/checks to AICRP and State Trials and reports of QRT and Monitoring Team from ICAR, Pantnagar Centre was adjudged the “Best Performing Kharif Centre 2010” amongst all the AICSIP (All India Coordinated Sorghum Improvement Project) Centers of the country, during 41st Annual Sorghum Group Meeting held at UAS, Dharwad from April 15-17, 2011 and Panntagar centre achieved the distinction again in 2019 for its “Immense Contribution in the Development of Many Promising Elite Lines in Sorghum leading to better livelihood and nutritional security in dryland ecosystems of India “ during 49th Annual Sorghum Group Meeting held at CCS HAU, Hisar from May 28-30, 2019.

5. Future Thrusts:

- Foliar disease resistance breeding through screening/ identification/validation of sources and recombination breeding and selection in segregating generation
- Intensive inter-varietal crossing to develop coloured grain genotypes
- Testing of nutritional quality traits of coloured grain genotypes
- Quality evaluation (IVDMD, ADF, NDF, Lignin, protein ) of stable BMR lines (8) and their use in breeding
- Standardization of screening techniques to identify sources of resistance to shoot fly, stem borer and pyrilla
- Development of high biomass sorghum genotypes with good lignocellulosic biofuel traits
- Selection in segregating generations of cross with CO (FS) 29 and CSV 33F and attempting new wide crosses to develop multi cut forage genotypes

B. Sorghum Pathology:

1. Significant Research Achievements:

- TH 39 and PSF 28, isolates of Trichoderma
harzianum and Pseudomonas fluorescens, respectively have been found to be best isolates for control of anthracnose (Colletotrichum graminicola) and zonate leaf spot (Gloeocercospora sorghi) foliar diseases.

- Soil solarization in combination with Trichoderma harzianum (TH 43 and TH 39) and Pseudomonas fluorescens (PSF 27) resulted in significant increase in plant growth and reduction of anthracnose severity in sorghum and hence can be recommended for management of anthracnose of sorghum.

- Eight grain sorghum genotypes (SPV 1659, SPV 1643, IS 14332, SPV 1685, SPV 1686, SPV 1713, SPV 1714 and SPV 1727) and four forage sorghum genotypes (UTFS 45, UTMCH 1302, UTMC 532 and PC 5) have been found consistently resistant against anthracnose and zonate leaf spot.

- Intercropping of sorghum with pigeonpea (3:3) reduces disease severity of anthracnose besides providing remunerative return.

- The isolates viz. TH 2, TH 14 and PSF 173, of Trichoderma harzianum and Pseudomonas fluorescens respectively, have been found to be best bio-control agent isolates for the management of Erwinia stalk rot.

- TH 32 isolate has been found promising for the management of sugary disease.

- Leaf whorl inoculation, stem injection and Root tip cut and dip methods were evaluated under field conditions for germplasm screening against stalk rot of sorghum caused by E.chrysanthemi. Root tip cut and dip method was found best for screening against ESR.

- Isolates of Colletotrichum graminicola and Gloeocercospora sorghi from leaves of diseased sorghum plants collected from different locations of Uttarakhund were characterized which differed morphologically, in cultural characters and at molecular level Using RAPD markers. Estimation of similarity indices showed a relatively high level of variability among isolates.

2. Research Papers:


Books:
- मुख्य फसलों व सब्जियों के रोग एवं प्रबंधन —अखिलेश सिंह व योगेन्द्र सिंह 2014. Directorate of Publication, G B Pant Univ. of Agric. & Technology, Pantnagar, India. 179 pp.

Lab Manual

Monograph
Kharayat, B. S. and Singh, Y. 2012. Zonate leaf
Chapters in Books


Popular Articles


3. Thesis Research:


17. Sweta Badoni. 2015. Isolation, characterization and evaluation of antagonistic potential of *Trichoderma* isolates against *Colletotrichum graminicola* and *Gloeocercospora sorghi* submitted for Ph.D. to GBPUAT under supervision of Dr. Y Singh.


4. Future Thrusts:

- Screening of germplasm for disease resistance
- Isolation, characterization and establishment of a repository of native Bio-control Agents (BCAs) from rhizosphere of sorghum
- Management of foliar diseases and bacterial stalk rot through Bio-control agents
- Studies on expression of defense genes in plants treated with BCAs
- Study of variability in C. graminicola causing anthracnose of sorghum

C. Sorghum Agronomy:

1. Significant Achievements:

The yield evaluation trials of pre-released varieties and hybrids of single cut and multicut forage sorghum for their response to different fertility levels are being conducted for developing cost effective cultivation practices for fodder purpose. Work has also been initiated on assessment of different forage crops as potential source of bio energy production under different cropping systems.

- The varieties S 540 for green fodder yield and S 541 and UTFS 49 for dry matter yield were found significantly better. Green forage as well as dry matter yield increased significantly with increase in nitrogen levels from 0 to 100 Kg/h.

- Green forage as well as dry matter yield increased significantly with increasing dose of nitrogen up to 80Kg N/ha and phosphorus up to 40Kg P$_2$O$_5$/ha. The combination of fertilizer N$_{80}$ P$_{80}$ being at par with N$_{120}$ P$_{60}$ caused significantly higher green forage and dry matter yield as compared to other combinations.

- Inoculating sorghum seeds with Azospirillum caused significant increase in green forage and dry matter yield as compared to non-inoculation. The economic analysis indicated that application of 100% RDF and seed inoculation with Azospirillum caused significant increase in net return as well as rupees per rupee invested.

- The varieties UTMC 532, GK 909 and SSG 59-3 (check) and hybrids UTMCH 1302, UTMCH 1304, SPH 1626, SPH 1627, CSH 20 MF(check) and CSH 24 MF(check) gave significantly highest total green fodder yield. A dose of 150 Kg N/ha was found to cause significantly more fodder yields as compared to remaining nitrogen levels. Green as well as dry fodder yields, increased significantly with each increasing level of nitrogen with highest at 150 Kg N/ha as well as net monetary returns.

- 75% of recommended N + Azospirillum inoculation and 75% of recommended N + 25% N through FYM were best for green as well as dry fodder yield and net return in terms of Rs./ha. 50 0% RDF + 25% N through FYM + Azospirillum, 75% RDF + 25% N through FYM) and 50% RDF + 50% N through FYM were other good INM practices.

- Integrated nutrient dose of 100% RDF + 25 Kg Zinc Sulphate/ha was best for green as well dry fodder yield besides various growth parameters like leaf stem ratio and plant height.

- Inter cropping of 1:1 sorghum with Pillipesara gave highest net return and benefit cost ratio followed by 2:2 sorghum intercropping with Pellipesara (Rs.19, 625/ha). Besides, 2:1 inter cropping of sorghum with Phillipesora gave highest dry fodder yield.

- Plant spacing of 45x15cm gave maximum green cane yield, fodder yield and juice yield. Application of 120 Kg N/ha gave maximum and significantly highest green cane and fodder yield however, for juice yield this treatment was at par with 90 Kg N/ha. Plant spacing did not exert any significant effect on juice yield however, it increased significantly with increased Nitrogen level from 30 to 90 Kg N/ha.

- 150% RDF gave highest yield. The genotype SPV
SPV 1754 gave highest green as well as dry fodder yield. SPV 1754 responded as significantly best genotype at 150% RDF for green fodder yield (740.74 q/ha). For dry fodder, SPH 1467 gave highest yield at 100% RDF but was at par with SPV 1754 at 50% and 100% RDF, and with SPV 1753, SPV 1754 and SPH 1467 at 150%RDF. Stem girth increased significantly with increasing doses of RDF.

- No significant yield difference as compared to Control (conventional tillage + RDF) was observed under different tillage practices and INM doses. Conventional tillage with 100% RDF was best for GFY.

- Soil application of 100% RDF +15 Kg Zn + 15 Kg Fe gave highest GFY, DFY, net monetary returns and crude protein %.

- 150% more RDF gave significantly highest yield of green fodder as well as grain. The variety SPSSV 40 was significantly best for grain yield.

- The sweet sorghum variety CSV 19SS gave significantly highest green and dry fodder yield. The application of N@120Kg/ha was significantly best treatment for yield and net monetary returns. Sowing of sweet sorghum genotypes at seed rate of 60 Kg/ha gave good yield of highly digestible fodder.

- Sowing on 15th April gave highest cane yield, juice yield and juice quality. High brix and high sucrose content was recorded in 15th May sowing.

- Millable cane yield increased significantly with increase in nitrogen levels, however, sowing done at 30 x 15 cm spacing yielded significantly more millable canes. Juice% and Brix (%) Increased significantly by application of 100 Kg N/ha. Wider spacing though increased the brix but spacing did not influence significantly the juice and brix per cent.

- Application of 150% more dose of fertilizers than recommended dose of fertilizer (RDF) resulted in significant increase in grain and green fodder yield, cane yield, stover yield, juice yield, cost benefit ratio and net monetary return.

- Application of 120 Kg N/ha gave significantly highest green (598.5q/ha) and dry fodder (148.4q/ha) yield along with net monetary returns and cost: benefit ratio.

- At both the cutting green fodder and dry fodder yield increased significantly with increasing fertility levels. There was a increasing trend in green and dry fodder yields from 50% to 125% RDF. Nitrogen content and nitrogen uptake, net return and B: C ratio increased significantly with increasing dose of fertility.

- Full package of practices (FPP) produced significantly highest green fodder and dry fodder yield. Important management component had greater influence on green fodder yield and dry fodder yield. In order of importance, most important component was fertilizer application followed by weed management.

- The green fodder yield increased significantly with increase in nutrient supply. 100% RDF gave significantly highest green fodder yield. Intercropping systems of sole cowpea gave significantly highest green fodder yield (628.6 q/ha) while intercropping of sole cluster bean had significantly highest digestibility percent.

2. Research Publications:


13. Verma SS, Ghanghas Vikas, Joshi YP and Chandra R 2006. Effect of zinc levels on grain and fodder yield of forage sorghum genotypes in northern India Pantnagar J. Res. 4: (1) 8-11.


Popular articles


3. Thesis Research:

1. R. Chandra. 2000. Studies on yield capability of different sorghum (Sorghum bicolor) genotypes at varying levels of N and P submitted for M. Sc. Ag. to GBPUAT under supervision of Dr. O.P. Singh.


Dr. S S Verma.


7. Shyam Singh. 2009. Studies on integrated nutrient management in sweet sorghum and \textit{Phillipesara} intercropping system submitted for Ph.D. to GBPUAT under supervision of Dr. Kewalanand

8. Amit Prasad Timilsina. 2010. Effect of row spacing and sowing time on performance of sweet sorghum varieties submitted for M. Sc. Ag. to GBPUAT under supervision of Dr. Kewalanand

9. Pramod Kumar Dubey. 2012. Response of sweet sorghum \([\textit{Sorghum bicolor} \text{(L.) Moench}]\) varieties to different seed rates and nitrogen levels submitted for Ph.D. to GBPUAT under supervision of Dr. Kewalanand

4. Future Thrusts:

- Evaluation of improved agronomic management practices for cost effective fodder production under different cropping systems
- Evaluation of forage crops for bio energy potential under different fertility levels of organic and inorganic fertilizers.