

COMPENDIUM OF CONCLUDED RESEARCH PROJECTS (1986 - 2001)

राष्ट्रीय काजू अनुसंधान केन्द्र

(भारतीय कृषि अनुसंधान परिषद्)

पुत्तूर - 574 202, दक्षिण कन्नड, कर्नाटक



भाकूअनुप
ICAR

National Research Centre for Cashew

(Indian Council of Agricultural Research)

Puttur - 574 202, Dakshina Kannada, Karnataka



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NRCC

Published by

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September 2002

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KV Nagaraja

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R Muthuraju

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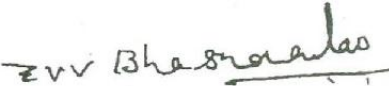
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PREFACE

The Quinquennial Review Team (QRT) constituted by ICAR, New Delhi, in 1982, under the chairmanship of Dr. A. Abraham, after reviewing the entire research work on cashew recommended delinking of cashew research from CPCRI, Kasaragod and establishing separate National Research Centre for Cashew (NRCC). Based on this suggestion, NRCC was established at Puttur on 18th June 1986. While starting the centre, 62 posts (scientific-14, technical-9, auxiliary-2, administrative-6 and supporting-31) were deployed from CPCRI, Kasaragod. Now there are 101 sanctioned posts (Director (RMP)-1, scientific-16, technical-26, administrative-15 and supporting-43) with Annual Budget of nearly 2.3 crores for the year 2001-2002.

During 1986-87, the projects on cashew, pursued at CPCRI, Regional Station, Vittal were discussed and some of the projects were closed. Based on the priority area suggested, new projects were formulated on all aspects of Cashew Production Technology. The progress made under all the projects is discussed in the annual Staff Research Council meetings of the centre, usually held during first quarter of every year. So far, 15 Annual Staff Research Council meetings have been held. Two Quinquennial Review Teams (for the period from 1986 to 1991 and 1992 to 1996) and two Research Advisory Committees (for the period from 1996 to 1998 and 1999 to 2001) constituted by ICAR, New Delhi have also reviewed the projects and based on the suggestions, technical programmes of the projects have been refined and implemented. A total of 32 projects have been concluded so far. In this compendium, details on these projects including duration, team of scientists, summary of results and publications are compiled. More elaborate final reports of these concluded projects are published in the Annual Reports of the center (Reference is cited along with project title). The reprints of the publications from all projects are available at NRCC library for the reference of scientists, research scholars and all those who are interested in cashew research. It is hoped that this publication will serve as reference for the status of research projects implemented so far at NRCC.

Place : NRCC, Puttur
Date : 24th Sept. 2002


EVV Bhaskara Rao
Director

1986

1. **Project Title** : Studies on the root and stem borer of cashew.
Ent.IV (176)
Ref: NRCC Ann.Rep. 1987

Duration : 1983-1986

Project Team : Mariamma Daniel

Objectives :

To study in detail the life cycle of the cashew stem and root borer (CSRB) with a view to control the pest population by chemical control and biological means.

Summary of Results :

Dimorphism was observed among adult beetles of CSRB. The average life cycle was 215 to 365 days and 230 to 381 days in males and females of CSRB respectively. The egg laying was noticed from November - June on the trunk of the tree upto one metre height, exposed roots, dried leaves and soil adhering to the base of the tree. Trees above two years of age were found to be attacked by this pest. Fungal disease caused by *Metarhizium anisopliae* has been observed on the grubs. Cashewnut shell liquid (CNSL) as an attractant was not effective against CSRB.

Publications:

Nil

1987

2. **Project Title** : Effect of time and severity of pruning
Hort.II (176)
Ref: NRCC Ann.Rep. 1988

Duration : 1984-1987

Project Team : E. Mohan

Objectives :

- i) To find out exact time of pruning.
- ii) To find out effect of severity of pruning.
- iii) To increase the yield/tree.

Summary of Results :

Pruning of leader shoots of trees of nine year old seedling progeny of M 76/2 in July and August doubles the yield/tree (9.2 kg) over the control (4.3 kg). The increased yield in leader shoot pruned trees has been attributed to higher number of bisexual

flowers (109, and 111, control 58.2), % productive laterals (58 and 69%, control 39%) and higher leaf surface area/shoot (1152 and 1310 cm², control 666 cm²)

Publications :

Nil

3. **Project Title** : Varietal improvement of cashew.
Gen.II (176)
Expt.III. Comparative yield trial.
Ref. NRCC Ann.Rep. 1988
- Duration** : 1972-1987
- Project Team** : P.M. Kumaran, K.V.J. Mohan, K.R.M. Swamy and Thimmappaiah

Objectives :

- i) To characterize and evaluate high yielding types in cashew.
- ii) To select suitable varieties for the area.

Summary of Results :

Among the 16 cashew types evaluated at CPCRI, Regional Station, Vittal, M 10/4 and M 44/3 (varieties of Vridhachalam origin) were found to be high yielding (M 10/4 - 45.35 kg, M 44/3 - 41.64 kg cumulative yield for 10 years) and possessing desirable characters like dwarfing habit, lower number of non-flowering laterals and higher fruit set. These varieties have been recommended for large scale adoption.

Publications :

Nil

1988

4. **Project Title** : Effect of irrigation on cashew.
Agr.III (176)
Ref: NRCC Ann.Rep. 1988
- Duration** : 1986-1988
- Project Team** : N. Yadukumar

Objectives :

- i) To find out response of cashew to supplementary irrigation during summer.
- ii) To work out critical periods of irrigation.
- iii) To work out economics of irrigation.

Summary of Results :

Irrigating 13 year old cashew trees planted at 8 m x 8 m spacing at 200 litres/tree

at fortnightly intervals from November to March helped in realizing two fold increased yield (control 546 kg/ha, irrigated 1142 kg/ha) and net profit of Rs. 12,508/ha compared to Rs. 5,644/ha in control.

Publications :

Yadukumar, N. and Mandal, R.C. 1994. Effect of supplementary irrigation on cashew nut yield. Water management for plantation crops - problems and prospects. Centre for Water Resource Development and Management. pp.79-84.

5. **Project Title** : Developing an yield index for cashew
Stat.III(176)
Ref: NRCC Ann.Rep. 1987 and 1988
- Duration** : 1987 - Project suspended in1988 due to transfer of Scientist
- Project Team** : S. Bhagavan

Objectives :

To develop an yield index for cashew.

Summary of Results :

The correlations for height of tree, canopy growth which can be approximated to a constant multiple of product of EW and NS spread, average number of fruits/unit area, hundred nut weight and yield have been worked out. Yield forecast model developed proved to be quite satisfactory (3% deviation) for individual trees while it is not satisfactory for the entire plot (deviation upto 12%)

Publications :

Bhagavan, S. and Kumaran, P.M.1988. Yield and yield attributes in cashew - An analysis through multi variate approach. PLACROSYM VIII 28-30 Dec. 1988. Cochin, Kerala. *J. Plantn. Crops* **18** (Supplement):351-355.

6. **Project Title** : Software development and computerized data base management
Stat IV(176)
Ref: NRCC Ann. Rep. 1987
- Duration** : 1987 - Project suspended in1988 due to transfer of Scientist (S. Bhagavan)
- Project Team** : S. Bhagavan, EVV Bhaskara Rao and TV Sathyanandan

Objectives :

Supporting the activities of the two minimission (Increasing production and Increasing productivity) of the centre by computerizing the information retrieval, data base management and statistical service.

Summary of Results :

- 1) An utility package has been prepared for quick retrieval of information on desired subject / author related to cashew.
- 2) Allotment of grafts has been computerized with a view to establish a database on varieties supplied to various locations.
- 3) A database has been prepared for retrieval of information on National Cashew Germplasm collections including exotic collections.
- 4) Statistical softwares have been developed to support the research activities of NRCC.

Publications :

Nil

1990

7. **Project Title** : Effect of graded doses of NPK fertilizers on the productivity of layers and seedlings.
Agr.1(a)
Ref: NRCC Ann.Rep. 1990-91

Duration : 1979 - 1990

Project Team : N. Yadukumar, K.B. Abdul Khader and R.C. Mandal

Objectives :

- i) To study nutritional requirement of cashew plants raised by seedlings and air-layers.
- ii) To study the relationship between N, P and K contents of leaf and soil with yield and to draw economically viable fertilizer schedule.

Summary of Results :

Linear trend in yield of air layers (prepared from a single mother tree) of more than 8 year old with increased dose of N from 250 g (4.34 kg/tree) to 750 g/tree/year (6.73 kg/tree) was observed. Corresponding increase in leaf N from 1.57% in trees receiving 250 g N to 1.72% in trees receiving 750 g N has been observed. Based on the results, application of 750 g N, 150 g each of P_2O_5 and K_2O /tree/year from 8th year onwards has been recommended.

Publications :

Nil

8. **Project Title** : Biology and Bionomics of Insect Pests of Cashew.
Ent.I (176)
Ref: NRCC Ann.Rep. 1990-91
- Duration** : 1972-1990
- Project Team** : D. Sundararaju, S. Devasahayam, C.P. Radhakrishnan Nair,
P.S.P.V. Vidyasagar, Mariamma Daniel, K.V. Nagaraja, G.B.
Pillai, B. Sathiamma, Vijay Singh, O.P. Dubey and V.A.
Abraham

Objectives :

- i) To study biology and bionomics of important pests of cashew with a view to evolve suitable control measures against them at the most vulnerable stages in their life cycle.
- ii) To have a better understanding of fundamental aspects such as longevity, fecundity, food and feeding habits, mating, oviposition of different pests and their seasonal abundance.

Summary of Results :

Based on seasonal abundance of tea mosquito bug (TMB), it is suggested that control measures are to be taken up at flushing, flowering and fruiting period. Accessions having least susceptibility to TMB have been identified. As most of the cashew pests except stem and root borer are suppressed by natural enemies, such as *Oxyopes schireta*, *Oxyopes* sp, *Phidippus patch*, *Phidippus* sp, *Matidia* sp, *Hyllus* sp, *Sycanus collaris*, *Sphedanolestes signatus*, *Irantha armipes*, *Occamus typicus*, *Endochus inornatus*, *Erythmelus helopeltidis*, *Perilampus microgastri*, *Apanteles euproctisiphagus*, *Panerotoma* sp and *Pseudospidemerus circumflexa*, there is greater scope of research on biological control of pests.

Publications :

- 1) Devasahayam, S. 1985. Seasonal biology of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera : Miridae) a pest of cashew. *J.Plantn.Crops* **13** : 145-147.
- 2) Devasahayam, S. 1988. Mating and oviposition behaviour of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera : Miridae) *J.Bombay Nat. Hist.Society* **85(1)** : 212-215.
- 3) Devasahayam, S and Radhakrishnana Nair, C.P. 1986. The tea mosquito bug *Helopeltis antonii* Signoret on cashew in India. *J. Plantn. Crops*. **14** : 1-10.
- 4) Nair, C.P.R., Abraham, V.A. and Pillai, G.B. 1974. Biology of *Metanastria hyrtaca* Crom., a defoliator of cashew. *J.Plantn. Crops* **2(2)** : 32-33.
- 5) Pillai, G.B. 1979. Pests. Pp. 55-72 in cashew (*Anacardium occidentale* L.) eds. Nair, M.K., Rao, E.V.V.B., Central Plantation Crops Research Institute, Kasaragod, India.

- 6) Pillai, G.B., Dubey, O.P. and Vijaya Singh, 1976. Pests of cashew and their control in India - a review of current status. *J.Plantn. Crops.* **4** : 37-50.
- 7) Pillai, G.B., Vijay Singh, Dubey, O.P. and Abraham, V.A. 1984. Seasonal abundance of tea mosquito, *Helopeltis antonii* on cashew in relation to meteorological factors. pp. 103-110, in Cashew Research and Development eds. Rao, EVVB and Khan, HH. Indian Society of Plantation Crops. CPCRI, Kasaragod, India.
- 8) Sathiamma, B. 1977. Nature and extent of damage by *Helopeltis antonii* S., the tea mosquito on cashew *J. Plantn. Crops.* **5** : 58-62.
- 9) Sathiamma, B. 1978., Occurrence of insect pests on cashew. *Cashew Bull* **15** (4) : 9-10.
- 10) Sathiamma, B. 1979. Varietal reaction of cashew to tea mosquito, *Helopeltis antonii* : S. (Hemiptera : Miridae), a major pests of cashew .Proc. PLACROSYM II. pp. 530-534.
- 11) Sathiamma, B. 1981. Occurrence of colour variants in *Helopeltis antonii* S. (Hemiptera : Miridae) on cashew. *Cashew Bull.* **18**(2) : 5.
- 12) Sathiamma, B. 1981. Nine minor insect pests on cashew. *Cashew Bull.* **18**(2) : 5-6.
- 13) Sathiamma, B. 1984. Biology of tea mosquito *Helopeltis antonii* Signoret reared on mango seedlings in the laboratory. *Cashew Bull.* **21** (1) : 6-8.
- 14) Sundararaju, D. 1979. A note on major pests, problems of cashew, coconut and arecanut and their control in Goa. Proc. PLACROSYM II pp. 513-516.
- 15) Sundararaju, D. 1984. Studies on cashew pests and their natural enemies in Goa. *J.Plantn.Crops* **12** : 38-46.
- 16) Thankamam Pillai, P.K. and Pillai, G.B. 1975. Note on shedding of immature fruits in cashew. *Indian J.Agric.Sci.* **45** (5) : 233-234.

9. **Project Title** : Pest Management in Cashew : Chemical control of pests of cashew.
Ent.III
Ref. NRCC Ann.Rep. 1990-91
- Duration** : 1972-1990
- Project Team** : N. Bakthavatsalam, Mariamma Daniel, A.S. Sukumaran, P.S.P.V. Vidyasagar, D. Sundararaju, Vijay Singh, M.V. George, B.G. Naik, O.P. Dubey, T.Premakumar, V.A. Abraham and G.B. Pillai

Objectives :

To evolve suitable chemical control schedule for combating the major pests of cashew effectively and economically.

Summary of Results :

- 1) Spraying endosulfan 0.05% at flushing, flowering and fruit set has been recommended. As spraying of endosulfan continuously may lead to development of resistance, monocrotophos (0.05%), quinolphos (0.05%) are to be altered in spraying. Benefit cost ratio of spraying endosulfan is higher (3.42) compared to decamethrin (1.67)
- 2) Dust formulation of carbaryl (5%) has been found to be effective against tea mosquito bug (TMB) wherever water is scarce.
- 3) Possibility of presence of female sex pheromone in three day old females of TMB has been indicated.
- 4) Mixture of coal tar and kerosene (1:2) has been found to be effective prophylactic control measure when applied twice a year in April / May and Nov / Dec against cashew stem and root borer (CSRB).
- 5) Phytosanitary measures like removal of dead trees in the plantation has been found to be necessary for checking further spread of CSRB incidence. Effectiveness of curative control measures depended on the stage of infestation. Removal of affected tissue and swabbing BHC (0.1%) at early stage of infestation is an effective method for controlling CSRB.

Publications :

- 1) Bakthavatsalam, N. and Sundararaju, D. 1990. Pathogenicity of *Oryctes* Baculovirus to cashew stem and root borers. *J. Biol. Control.* **4** (2) : 127-129.
- 2) Pillai, G.B. 1975. Tea mosquito a serious menace to cashew, *Indian Cashew J.* **10** (1) : 5-7.
- 3) Pillai, G.B. 1979. Pests in Cashew. Monograph on plantation crops. CPCRI, Kasaragod pp. 55-72.
- 4) Pillai, G.B. 1980. Pest problem in Cashew. *Cashew Casuerie.* **2** (2) : 3-10.
- 5) Pillai, G.B. Dubey, O.P., Singh, V. 1976. Pests of cashew and their control in India; A review of current status. *J. Plantn. Crops.* **4** (2) : 37-50.
- 6) Sundararaju, D. 1984. Chemical control of tea mosquito bug (*Helopeltis antonii* Sign) in cashew at Goa. *Cashew Casuerie.* **VI** (3) : 10.
- 7) Sundararaju, D. 1985. Chemical control of cashew stem and root borers *Plocaederus ferrugineus* L. at Goa. *J. Plantn. Crops.* **13** : 63-66.
- 8) Sundararaju, D. and N. Bakthavatsalam. 1990. Cashew Pest Management for coastal Karnataka. *The Cashew.* **IV** (3) : 3-6.
- 9) Sundararaju, D., Bakthavatsalam, N., John, N.J. and Vidyasagar, P.S.P.V. 1994. Presence of female sex pheromone in tea mosquito bug, *Helopeltis antonii* Sign. (Heteroptera : Miridae). *Entomon.,* **19** : 47-51.

10. **Project Title** : Quality evaluation in cashew.
Phy.V (176)
Ref: NRCC Ann.Rep. 1990-91

Duration : 1984-1990

Project Team : K.V. Nagaraja

Objectives :

To characterize high yielding varieties with respect to biochemical constituents like proteins, lipids, sugars, starch, tannins, phenols, ascorbic acid and CNSL.

Summary of Results :

Cashew kernels and apples from different varieties have been characterized for biochemical composition. An index for quality evaluation has been arrived. A variety with kernel protein content of > 35 g/100 g, sugar content of < 14 g/100 g and lysine content of > 50 µg/mg protein is desirable. These values are based on defatted cashew kernel flour. Out of thirty four varieties /accessions, 16 varieties qualify for the above criteria. Cashew kernel lipids are rich in triglycerides which are rich in unsaturated fatty acids. Glycolipids are poor in unsaturated fatty acids. Proteins extracted at pH 10 are better digested by Trypsin and α-Chymotrypsin. Pepsin digestion is better in pH 4 extracted proteins. Thermal denaturation of extracted cashew kernel proteins enhances the digestibility by Trypsin.

Publications :

- 1) Nagaraja, K.V. 1987. Proteins of high yielding varieties of cashew. *Plant Food for Human Nutrition*. **37** : 69-75.
- 2) Nagaraja, K.V. 1987. Lipids of high yielding varieties of cashew. *Plant Foods for Human Nutrition*. **37** : 307-311.
- 3) Nagaraja, K.V. 1989. *In vitro* digestibility of cashew kernel proteins. *Current Science*. **58** : 769-771.
- 4) Nagaraja, K.V. 1992. Composition of cashew shell. *J. Plantation Crops*. **20**:73-74
- 5) Nagaraja, K.V. and Krishnan Nampoothiri, V.M. Chemical characterization of high yielding varieties of cashew. *Qual Plant food Humn Nutr*. **36** : 201-206.

11. **Project Title** : Propagation studies in cashew.
Hort.III (176)
Ref: NRCC Ann.Rep. 1990-91

Duration : 1977-1990

Project Team : S. Nagabhushanam, Room Singh, K.R.M. Swamy, K.N. Murthy, E. Mohan and K.V.J. Menon

Objectives :

- i) To standardize vegetative propagation methods in cashew and to make available clonal progenies of released / pre-released cashew varieties to growers.
- ii) To study the feasibility of improving the unthrifty cashew trees by top working.
- iii) To assess the relative performance of seedlings and airlayers in a field trial.
- iv) To study the stock-scion interaction at nursery stage.

Summary of Results :

Softwood grafting technique is the best method for commercial multiplication of cashew varieties. Monsoon period (Jun - Oct) is the best period for grafting with more than 60% graft success. Mortality of top worked trees was observed although the grafts success was quite high. Stock-scion interaction was not observed at nursery stage. VTH 174, NRCC Sel-1 and V-1 varieties with medium sized nuts and producing vigorous seedlings were found to be ideal root stock for softwood grafting.

Publications :

- 1) Menon, M.A. and Nagabhushanam, S. 1979. Mound layers of cashew (*Anacardium occidentale* L.). *Curr. Sci.* **48**(20) : 918-919.
- 2) Nagabhushanam, S. 1979. Vegetative Propagation in cashew - Review of work done at Vittal. *Acta Horticulturae*, No. **108** (1985) : 57-63.
- 3) Nagabhushanam, S. 1979. Preliminary studies on propagation of cashew by stooling and layering. *Acta Horticulturae* No. **108** (1985) : 286-287.
- 4) Nagabhushanam, S. 1982. Criteria for selection of scion material for propagation of cashew (*Anacardium occidentale* L.) by epicotyl grafting. *PLACROSYM*, **V** : 184-186.
- 5) Nagabhushanam, S. 1982. Epicotyl grafting in cashew. *Cashew Causeerie*. **4** (1) : 8-9.
- 6) Nagabhushanam, S. 1983. A study on epicotyl grafting in cashew. *Indian Cashew J.* **15** (1) : 13-16.
- 7) Nagabhushanam, S. and Menon, M.A. 1978. Techniques of Vegetative propagation in cashew. *Indian J. Forestry*. **1**(4) : 290-292.
- 8) Nagabhushanam, S. and Menon, M.A. 1980. Propagation of cashew (*Anacardium occidentale* L.) by etiolation, girdling and stooling. *The Plant Propagator*. **26** (1) : 11-13.
- 9) Nagabhushanam, S. and Murthy, K.N. 1979. Prospects of vegetative propagation in cashew (*Anacardium occidentale* L.) by air layering. *Indian Cashew J.* **3**(2) : 29-32.
- 10) Nagabhushanam, S. and Murthy, K.N. 1980. A field study on propagation of cashew (*Anacardium occidentale* L.) by air layering. *Cashew Bull.* **17**(4) : 17-18.

- 11) Nagabhushanam, S., Mohan, E. and Murthy, K.N. 1980. Juvenile growth characters of air layers and seedlings in four cashew (*Anacardium occidentale* L.) cultivars. *J. Plantn. Crops.* **8**(2) : 106-107.
- 12) Nagabhushanam, S., Murthy, K.N. and Mohan, E. 1980. A note on field establishment of cashew (*Anacardium occidentale* L.) air layers. *Indian J. Hort.* **37**(2) : 151-153.
- 13) Swamy, K.R.M. 1989. Vegetative propagation technique for commercial multiplication of cashew varieties. NRCC Tech. Bull., No. 1, 9 pp.
- 14) Swamy, K.R.M., Room Singh, and Mohan, E. 1990. Correlation of softwood graft success with weather parameters in cashew (*Anacardium occidentale* L.) *S. Indian Hort.* **38** : 291-300.
- 15) Swamy, K.R.M. and Mohan, E. 1991. Screening of cashew (*Anacardium occidentale* L.) varieties / types for root stocks at nursery stage. *The Cashew.* **5** (2) : 3-5.
- 16) Swamy, K.R.M., Bhaskara Rao, E.V.V., Nagaraja, B. and Nayak, M.G. 1993. Commercial propagation of cashew varieties. Paper presented at the Golden Jubilee Symposium on Horticultural Research - Changing Scenario, May,24-28,1993. I.I.H.R., Bangalore India.

1992

12. **Project Title** : Chemical control experiments against tea mosquito bug.
Ent.VII
Ref: NRCC Ann.Rep. 1992-93
- Duration** : 1989-1992
- Project Team** : N. Bakthavatsalam (upto Nov. 1991), P. Shivarama Bhat and D. Sundararaju

Objectives :

- i) To find out suitable dust formulation against tea mosquito bug (TMB) in young plantations.
- ii) To find out the ovicidal action and the residual toxicity of certain recommended insecticides against TMB.

Summary of Results :

- 1) Carbaryl 5% dust has been found to be suitable for management of TMB in young plantation wherever spraying is not feasible due to problems of transportation and shortage of water.
- 2) The insecticides such as phosalone (0.07%), endosulfan (0.05%), carbaryl (0.1%), quinolphos (0.05%), monocrotophos (0.05%), ethofenprox (0.015%), methyl

parathion (0.05%), dimethoate (0.05%) and decamethrin(0.028%) did not exhibit any ovicidal action against TMB.

- 3) Insecticides such as carbaryl, monocrotophos, phosalone, decamethrin and ethofenprox were highly toxic to first instar nymphs.
- 4) Among the recommended insecticides tried, maximum residual toxicity upto one week was noticed for carbaryl and monocrotophos followed by dimethoate.

Publications :

- 1) Sundararaju, D., Bakthavatsalam, N. and Bhat, P.S. 1993. Ovicidal activity and residual toxicity of certain insecticides to tea mosquito bug *Helopeltis antonii* Sign. (*Heteroptera Miridae*). *Pestology XVII* (2) : 14-19.
- 2) Bakthavatsalam, N., Sundararaju, D and Bhat, P.S. 1993. Chemical control of tea mosquito bug in cashew with dust formulations. *The Cashew*. 7 (3) : 12-13.

1993

13. **Project Title** : Screening and Biochemical evaluation of cashew germplasm in relation to tea mosquito bug infestation.
Adhoc Scheme
Ref: NRCC Ann.Rep. 1993-94
- Duration** : 1988-1993
- Project Team** : K.V. Nagaraja, D.Sundararaju, Joy N John (Nov.1988 - Feb 1992), P.S. Bhavanishankar Gowda (Apr 1989-Oct 1989), K. Prāsanna Rai (Apr. 1990 - Jul 1990) Venugopalakrishna Kurup (Mar 1992 - May 1993).

Objectives :

- i) To screen cashew accessions for tea mosquito bug (TMB) tolerance.
- ii) Comparative biochemistry of susceptible and tolerant cashew accessions.
- iii) To study bio-chemical changes in susceptible accession due to infestation.
- iv) Extraction and characterization of saliva from TMB.
- v) To study biochemical changes due to infestation in alternate hosts.
- vi) Enzymatic changes in susceptible accessions due to infestation.

Summary of Results :

Mass rearing technique for TMB has been standardized. Laboratory screening technique for TMB tolerance has been standardized. Tender shoots were most preferred for feeding by TMB. Among the accessions screened for TMB tolerance, VTH 153/1, exhibited moderately susceptible reaction. Infestation of cashew by TMB resulted in decreased leaf sugars, chl-a, and carotenoid pigments. Total phenols, OD phenols,

starch and lignin content in leaf and shoot increased during infestation. Infestation also resulted in cellular damage with increased leaching of small molecular weight compounds such as sugars, phenols and OD phenols. Infestation also resulted in increased conductance. Biochemical changes get manifested as early as 6 h after infestation.

Publications :

- 1) Annapoorna Rai.K., and Nagaraja, K.V. 1988. Tea mosquito *Helopeltis antonii* induced biochemical changes in cashew (*Anacardium occidentale*). *Cashew Bulletin*. **XXV** No.1 and 2, 8-11.
- 2) Nagaraja, K.V., Bhavanishankara Gowda, P.V., VenugopalaKrishna Kurup, V. and John, N.J. 1994. Biochemical changes in cashew in relation to infestation by tea mosquito bug. *Pl. Physiol. Biochem.*, **21**(2):91-97.
- 3) Sundararaju, D. 1993. Susceptibility of Cashew Accessions to *Helopeltis antonii* Sign. (Heteroptera : Miridae), in the pre-flowering phase. *J. Plantn. Crops*. **21**:50-53.
- 4) Sundararaju, D. and John, N.J. 1992. Mass rearing technique for *Helopeltis antonii* Sign. (Heteroptera : Miridae) - an important pest of cashew. *J. Plantn. Crops*. **20** : 46-53.
- 5) Sundararaju, D. and John, N.J. 1993. Susceptibility of cashew accessions to *Helopeltis antonii* Sign. (Heteroptera : Miridae) in the pre-flowering phase. *J.Plantn.Crops*. **21** (1):50-53.

1994

14. **Project Title** : Demonstration of beneficial effects of pruning in cashew.
Hort.II(a)
Ref.NRCC Ann.Rep. 1993-94
- Duration** : 1988-1994
- Project Team** : E. Mohan (1988-90) and M.G. Nayak (1990-94)

Objectives :

To demonstrate the beneficial effects of pruning on a large scale.

Summary of Results :

In old and unthrifty plantations, the leader shoot pruning is helpful in enhancing nut yield. The additional yield obtained by pruning compensates the extra cost involved in pruning. Thus, at least once in 2-3 years removal of dead woods and leader shoot can be practiced in old and unthrifty plantations.

Publications :

Nil

15. **Project Title** : Response of high yielding varieties of cashew to different levels of nitrogen.
Agr.I(b)
Ref: NRCC Ann.Rep. 1994-95

Duration : 1982-1994

Project Team : K.V.J. Mohan (1982-83), R.C. Mandal (1983-84), K.B.A. Khadar (1984-86), N. Yadukumar (1986-94), N.T. Bhat (1988-89) and Thimmappaiah (1988-91)

Objectives :

- i) To evaluate eight promising selections identified from the germplasm collection.
- ii) To compare seedlings and grafts of the above selections.
- iii) To assess to three levels of nitrogen in terms of growth, flowering habit and yield.

Summary of Results :

Linear response for yield was observed for N application from 250 g (cumulative yield of 2271 kg/ha for first 10 years) to 750 g/tree (cumulative yield of 3175 kg/ha for first 10 years). Among different varieties, highest cumulative yield for seven years was recorded in M 6/1 (seedlings -19.46 kg/ha and grafts - 15.44 kg/ha) and lowest in T.No.1 (seedlings - 12.05 kg/ha, grafts 9.83 kg/ha). Net profit realized at the lower fertilizer dose (250 g N/tree) was Rs. 15461/ha and it doubled to Rs. 31155/ha in the case of highest dose (750 g N/tree).

Publications :

Nil

16. **Project Title** : High density planting of cashew.
Phy-III
Ref: NRCC Ann.Rep. 1996-97

Duration : 1982-1994

Project Team : L.P. Misra (1982-85), N. Yadukumar (1986-94) and E. Mohan (1982-90)

Objectives :

- i) To study growth behaviour under high density planting.
- ii) To study root distribution pattern during initial years.
- iii) To study photosynthesis and other physiological parameters in different stages of growth before thinning/after thinning and at different density situations.
- iv) To increase productivity of cashew per unit area.

Summary of Results :

- 1) In high density planting of cashew, optimum ground coverage is obtained with simultaneous high yield per unit area upto six years after planting and beyond that either ground coverage can be manipulated by pruning overlapping branches limiting light interception to 80 % every year or by thinning the plant population to 50 to 25 % depending upon the original plant densities per unit area. Significant higher photosynthesis and higher irradiance in widely spaced trees were observed.
- 2) Simultaneous increase in Pn (Net Photosynthesis) values for the remaining trees after thinning was also observed. Decline in yield/ha was observed seven years after planting in the case of plant densities - 2500 trees/ha (2m x 2m) and 1111 trees/ha (3m x 3m) plots and 11 years after planting in the case of 625 trees/ha (4m x 4m) plot. Steady increase in yield after thinning was also observed till the ground coverage and light interception reached peak. Studies on root spread and depth indicated that the roots of the closely spaced trees reached deeper depth than widely spaced trees. Moisture content at deeper depths was minimum in plot where trees were closely spaced compared to widely spaced trees. Dry branches produced was maximum in high density plots compared to plots with minimum plant density. Cumulative yield data for the first 12 years after planting showed that maintaining a plant density of 625 trees/ha (4m x 4m) for the first 11 years and thinning after that to 50 % (8m x 5.7 m x 5.7 m) resulted in maximum yield of nuts (4.94 t/ha)

Publications :

Balasimha, D. and Yadukumar, N. 1993. Effect of plant density on photosynthesis in cashew. *Ind. J. Pl. Physiol.* **36**(1):5-7.

1996

17. **Project Title** : Development of suitable cashew based cropping systems. Inter and mixed cropping with cashew
2.6
Ref: NRCC Ann.Rep. 1998-99
- Duration** : 1987-96
- Project Team** : N. Yadukumar (1987-96), B. Nagaraja (1990-96) and Mohan (1987-90)

Objectives :

To evaluate / study performance of inter and mixed crops in cashew with special reference to light profiles, photosynthetic characteristics, growth, yield and economics.

Summary of Results :

Growing cover crops could check soil erosion, Sustained additional income can be obtained by growing intercrops. The crops tested were pigeon pea, tapioca and sweet potato (food crops), castor and sunflower (oil seeds), and biennial and perennial crops such as pineapple and guava and the pulp and fuel wood perennials like acacia, casuarina and subabul. During the initial eight years significant increase in growth, light interception, photosynthesis characteristics and yield in the main crop was observed when pineapple was grown as an intercrop. Growing tree species affected the maincrop in terms of growth, photosynthetic character and yield in comparison to cashew alone, cashew + pineapple and cashew + mucuna. Pineapple and mucuna improved soil moisture and nutrient content enhancing microbial activity leading to a positive effect on main crop. Pineapple fetched a maximum profit of Rs. 57,965/ha till eight years followed by growing casuarina for first 5 years and subsequently growing pineapple in the same plot, which led to a profit of Rs. 41,269/ha. Though profit realized is substantial by growing tree species like casuarina and acaia the cumulative yield of the main crop reduced significantly compared to cashew + pineapple and cashew + mucuna and cashew alone.

Publications :

- 1) Palanisamy, K. and Yadukumar, N. 1993. Photosynthesis in relation to radiation and leaf position in cashew trees. *Photosynthetica.*, **29**(1): 113-116.
- 2) Palanisamy, K., Yadukumar, N. and Bhaskara Rao, E.V.V. 1993. Physiological characteristics of cashew in intercropped systems. *Pl. Physiol. Biochem.*, **20** (2):99-101.
- 3) Yadukumar, N., Nagaraja, B. and Sreenath Dixit. 1994. Pineapple as an intercrop with cashew. *SAIC Newsletter.* **4**(2):6.

1997

18. **Project Title** : Studies on biochemical changes during storage of cashewnuts and apples.
Investigations into causes of nut rejects during harvest storage and processing.
Biochem-1
Ref: NRCC Ann.Rep. 1997-98
- Duration** : 1990-1997
- Project Team** : K.V. Nagaraja
D. Balasubramanian (1995-97)

Objectives :

- i) To study biochemical changes with reference to proteins, sugars, lipids, amino acids and lysine during storage of rawnuts both at ambient and low temperatures.

- ii) To study the biochemical changes in cashew apples with reference to amino acids, sugars, ascorbic acid and tannins during storage at ambient and low temperatures.
- iii) To study biochemical changes with reference to proteins, sugars, lipids, and amino acids during development of cashewnuts and apples.
- iv) Investigations into factors responsible for kernel rejects.

Summary of Results :

Kernel sugars, starch and CNSL content decreased during storage. Raw nuts could be stored for 16 months without any quality deterioration. As the biochemical composition is different, in nuts harvested at different maturity stages, it is better if the fully matured nuts are harvested. Cashew apples could be stored for 10 days at refrigerated temperature (6-10°C) in polythene pouches. Among the various factors investigated for kernel rejects, immature nuts and floaters contribute to the kernel rejects during processing. Storage period upto 16 months, grading before processing, processing with and without steam roasting, steam roasting time varying between 5 and 20 min, initial raw nut moisture content ranging from 5 and 14 per cent and time delay in drying the freshly harvested nuts upto 60 days did not affect the % kernel rejects.

Publications :

- 1) Nagaraja, K.V. 1992. Harvesting and post-harvest care of cashew nuts and apples. *Proc. of National Workshop on Integrated Development of Cashew*. Kannur, 01-02 February, 1992.
 - 2) Nagaraja, K.V. 1994. Utilisation of cashew apple. *Cashew Day Souvenir*. OUAT, Bhubaneswar.
 - 3) Nagaraja, K.V. 1996. Biochemical changes during storage of cashew. *Plant Physiol. and Biochem.* **23**, 163-168.
 - 4) Nagaraja, K.V. and Prabhu, G.G. 1996. Investigations into factors influencing kernel rejects during processing - A preliminary study. National Seminar on Development of Cashew Industry in India. 14-15 Dec. 1996.
19. **Project Title** : Economic feasibility of drip irrigation and graded doses of NPK on the productivity of cashew.
2.5:
Ref: NRCC Ann.Rep. 1998-99
- Duration** : 1987-97
- Project Team** : N. Yadukumar
- Objectives :**
- i) To ascertain the effects of drip irrigation with graded doses of NPK on the growth, yield and quality aspects of cashew.
 - ii) To ascertain the economics of drip irrigation along with fertilizer application.

Summary of Results :

Irrigation significantly increased number and weight of nuts/tree. Highest yield was obtained when trees were irrigated at 80 l/tree once in four days from second fortnight of December to end of March compared to lowest level of irrigation (20 l/tree) and no irrigation. The crop responded significantly to the highest level of NPK fertiliser (750 g N: 187.5 g each of P_2O_5 and K_2O /tree) resulting higher yield than those receiving lower dose (250 g N: 62.5 g each of P_2O_5 and K_2O /tree) and no fertilizers. Interaction effect of both irrigation and fertilizer was not observed. However, highest economic yield was obtained from trees receiving highest level of irrigation and fertilizer. Increased yield due to irrigation and fertilizer application separately could be attributed to increase in exposed canopy area, photosynthetic rate, light interception, nut retention, number and weight of nuts/tree. Though the interaction effect of irrigation and fertilizer was not observed for the above yield attributes, increasing trend was observed with the level of irrigation and fertilizers. Irrigation at 20, 40 and 60 l/tree significantly increased kernel protein content compared to the nuts of trees receiving highest irrigation at 80 l/tree and no irrigation. It was concluded that irrigating cashew trees at the rate of 80 l/tree once in 4 days from second fortnight soon after the flowering initiation till March is beneficial in increasing yield for the first eight years in the grafted plants. It is also beneficial if fertilizer (750 g N, 187.5 g each of P_2O_5 and K_2O /tree per year) is applied in two split doses (two thirds in September and one third in February) along with irrigation.

Publications :

Yadukumar, N. and Balasimha, D. 2000. Effect of drip irrigation and fertilizer levels on photosynthesis in cashew. In: National Seminar on recent advances in Plant Biology - An interdisciplinary approach to unravel plant function. CPCRI, Kasaragod, 3-5 Feb. 2000.

1998

20. **Project Title** : Development of suitable cashew based cropping systems. Cashew with forest tree species.
2.6.
Ref: NRCC Ann.Rep. 1998-99
- Duration** : 1990-98
- Project Team** : N. Yadukumar
B. Nagaraja (1990-1996)

Objectives :

- i) To evaluate forest tree species as intercrops in cashew.
- ii) To work out economics of different cropping systems.

Summary of Results :

Growing tree species like acacia and casuarina as intercrops led to reduced yield of cashew. Reduction in yield of cashew continued for three years after removal of

these tree species. Growing ailanthus, subabul and bamboo, however, did not influence cashew yields for the first six years. The total income from cashew intercropped with ailanthus, subabul or bamboo was lower. Cashew in combination with casuarina and acacia for the first six years and growing cashew alone after removal of tree species upto eight years is not desirable as it affects main crop yield. It is beneficial to take up high density planting of cashew rather than growing forest tree species as intercrops in cashew plantation under normal spacing (main crop).

Publications :

Nil

21. **Project Title** : Formulating IPM schedules for stem and root borers infesting cashew.
3.1
Ref: NRCC Ann.Rep. 1998-99
- Duration** : 1990-98
- Project Team** : N. Bakthavatsalam (1990-91), P.S. Bhat (1992-96), T.N. Raviprasad (1996-98), K.V. Nagaraja (1993-95, 1997-98) and Sundararaju (1997-98)

Objectives :

- i) To evaluate the efficacy of various prophylactic and curative measures in checking cashew stem and root borer (CSRB) incidence.
- ii) To record the population dynamics of the pests.
- iii) To standardize mass rearing techniques for the pests under laboratory conditions.
- iv) To identify natural enemies on the pest and evaluate entomopathogenic fungi against the different stages of the pest.
- v) To investigate the presence of response inducing volatiles and sex pheromones in CSRB species.

Summary of Results :

Among the fumigants tested EDB ampoules and chloroform induced the highest mortality (71.8 and 59.2 % respectively). Recovery was higher in trees having initial attack only, wherein stem swabbing of lindane 0.2% resulted in 88.9 % recovery followed by monocrotophos 0.2% (87.5%), chlorpyrifos 0.2% (87.5%) and neem oil 5% (28.6%). Trees at moderate or severe stages of attack showed less than 25.0 % recovery, indicating that trees can respond to treatment upto a certain level of bark damage. Observations on population dynamics of the pest indicated a mixed field population of two species *Plocaederus ferrugineus* and *P. obesus*. Infestation was mainly noticed in the collar region, followed by root and stem regions. The young grubs were observed during February to June indicating that this is the period during which infestation takes

place. Egg collection method using cotton tape wrapped on the cashew twig was developed. Among the three entomopathogenic fungi namely, *Beauveria bassiana*, *B. brongniartii* and *Metarhizium anisopliae* evaluated for their virulence. *B. bassiana* was found to be the most virulent with LD₅₀ of 1.41 x 10⁶ spores/ml. A wind tunnel glass olfactometer was designed at NRCC for preliminary studies on response of adult beetles to plant volatiles and sex pheromones. Fresh frass and bark of infested tree elicited maximum response from both male and female adult beetles. Under free choice conditions, highest egg laying was observed on bark of infested tree.

Publications :

- 1) Bhat, P.S. and Raviprasad, T.N. 1996. Pathogenicity of entomopathogenic fungi against cashew stem and root borer *Plocaederrus ferruginus* L. Coleoptera : Cerambycidae) *J. Plantn. Crops.* **24**(Supplement) : 265-271.
- 2) Sundararaju, D. and Bakthavatsalam, N. (1990). Cashew pest management for coastal Karnataka. *The Cashew.* **4**(3):3-6.
- 3) Sundararaju, D., Ravi Prasad, T.N. and Bhat, P.S. 1999. Pests of cashew and their Integrated Management. In: "IPM systems in Agriculture". Vol. VI. - Cash crops (eds Upadhyaya *et.al.*). Aditya Publication Pvt. Ltd., New Delhi, pp 524-544.

22. **Project Title** : Evaluation and mass multiplication of biocontrol agents against tea mosquito bug.
3.2
Ref: NRCC Ann.Rep. 1998-99.
- Duration** : 1990-98
- Project Team** : D. Sundararaju (1990-93, 1996-98) and T.N. Raviprasad (1993-98)

Objectives :

To identify and utilize suitable parasite or predator against tea mosquito bug (TMB) and other sucking pests as a biological control component to develop IPM strategy.

Summary of Results :

Existence of four species of hymenopteran egg endoparasitoids of TMB viz., *Telenomus* sp. laricis group (Fam : Scelionidae), *Chaetostricha* sp. (Fam : Trichogrammatidae), *Erythmelus helopeltidis* Gah. and *Gonatocerus* sp. (Fam : Mymaridae) was documented. *Telenomus* sp. was found to be dominant species and encountered throughout the year. The highest egg parasitism upto 68.9 % was recorded even in the plot where insecticide was sprayed. For estimation of TMB population and damage, 52 leader shoots from any one quadrant of the tree can be used. Goa 11/6, a TMB escape accession recorded an yield of 6-7 kg/tree even under unsprayed condition in 7th - 8th year of planting.

Publications :

- 1) Sundararaju, D. 1993. Studies on parasitoids of tea mosquito bug, *Helopeltis antonii* Sign. (Heteroptera : Miridae) on cashew with special reference to *Telenomus* sp. *J. Biol. Control.* 7:6-8.
 - 2) Sundararaju, D., Ravi Prasad, T.N. and Bhat, P.S. 1998. Preliminary studies on distribution of *Helopeltis antonii* Sign. and estimation of its population on cashew. *Recent Advances in Plantation Crops Research* (Eds-Muralidharan, N. and Rajakumar, R.) Allied Publications Ltd., New Delhi. pp.307-313.
 - 3) Sundararaju, D. 2000. Insects associated with extrafloral nectaries of cashew leaves. *J. Plantn. Crops*, 28 : 175-178.
 - 4) Sundararaju, D. 2000. Foraging behaviour of pollinators on cashew. *The Cashew.* 14 (4) : 20-26.
23. **Project Title** : Developing database on processing aspects of cashew industries in India
4.2
Ref: NRCC Ann.Rep. 2001-2002
- Duration** : 1995 - 1998
- Project Team** : D.Balasubramanian

Objectives :

- i) To study the prevailing processing practice, system of storage, plant and personal hygiene etc., of cashew nut processing industries of different region to refine the technique of processing for efficient outturn.
- ii) To study the employment potential and production and equipment needs of these industries to forecast the impact of mechanization in these regions.
- iii) To work out the processing cost in cashew nut processing at various stages of operation.

Summary of Results :

The capacity utilization of cashew nut processing industries is lower than installed capacity primarily due to raw nut shortage and financial reasons. Well-established industries import raw nuts to overcome shortage and operate throughout the year. The capacity utilization ranges between 100-5000 MT/year. Government approved wages are strictly followed and the workers are motivated by providing medical facilities and share in the profit. The women labourers are engaged in shelling, peeling and grading accounting to 90 % of total labour force in the industry. Men employees are engaged in drying raw nuts, stacking bags, roasting, kernel drying and packaging.

Raw nuts are obtained from producers, local markets, commission agents and imports. Visual and cutting tests are used to ascertain the raw nut quality while procuring.

Gunny bags are used for raw nut storage and individual or common warehouses are utilised for this purpose. The raw nuts are sun dried immediately after procurement and the metallic sound (while rubbing handful of nuts) is believed to be the end point for safe storage. Raw nut grading is not followed in the industry as processing is not mechanised at all stages of processing

While shelling, contact of cashewnut shell liquid (CNSL) leads to health hazard, but none of the industry has taken up any measure to overcome this problem. In steam boiling the nut conditioning parameters viz., steam pressure and period of exposure and in drum roasting; the temperature and the rotational speed of drum are considered as critical parameters and they differ with quality and of nut origin. Kernels are dried in hot chamber but mode of hot air supply varies with the type of system. Cross flow drier is the latest introduction, wherein kernels can be dried in 50 % of the time required in tunnel dryer. Drying chamber is constructed with brick and mortar to retain the thermal energy for longer time. The heat utilisation efficiency of the system is improved by re-circulating hot air. The average shelling capacity ranges from 10-40 kg raw nut /head/ day and the peeling capacity ranges from 8-14 kg kernels /head /day. The whole kernel recovery is 90 - 95 % and is 65 - 70 % in shelling and peeling respectively.

Plastic and aluminium containers are used for material conveyance in the factories. The factors considered for grading kernels are wholesomeness, colour and size and about 26 grades are segregated for export and up to 35 grades for domestic supply. Vita packing system is mostly followed for packaging kernels (11.34 Kg) in tin containers with CO₂ flushing. After the introduction of Total Quality Management (TQM) by the importing countries, processors are gradually switching over to Moulded Vacuum Packaging (MVP). Expellers are widely used to extract CNSL from shells after extracting kernel and an average of 200 ml crude oil can be extracted from 1.0 kg shell. Litmus paper test is normally conducted to determine the quality of CNSL. Though the cost of processing for steam boiled nuts (Rs.5.16 per kg) is higher than drum roasted nuts (Rs.3.17 per kg), the recovery of CNSL gives extra revenue to the industry.

Publications :

- 1) Balasubramanian, D. 1998. Quality maintenance of raw cashew nuts. *The Cashew*. **12(3)** : 137-142.
- 2) Balasubramanian, D. 1998. Cashew industries in India. In. Harvest and post harvest of horticultural crops. Ed. Bosco S.J.D., Central Plantation Crop Research Institute, Kasaragod, Kerala, India. pp: 102-110
- 3) Balasubramanian, D. 2000. Physical properties of raw Cashew nuts. *J. agric. Engg Res.* Vol.78. No.3. pp: 291-297
- 4) Balasubramanian, D. 2000. Performance of cashew nut processing in Andhra Pradesh-A case study. *The Cashew*. **14(4)** : 7-17.
- 5) Balasubramanian, D. 2000. Status report of cashew industries in Dakshina Kannada. *The Cashew*. **14(2)** : 12-25.

24. **Project Title** : Design, development and evaluation of raw cashew nut grader
4.3
Ref: NRCC Ann. Rep. 2001-2002

Duration : 1995-1998

Project Team : D. Balasubramanian

Objectives :

Developing and evaluating power operated raw cashew nut grader.

Summary of Results :

- 1) The mass of 100 nuts and true density of raw cashew nuts increased with increased moisture content. The porosity and bulk density decreased linearly with the increased moisture content.
- 2) The co-efficient of friction on various surfaces increased with increased moisture content. Cardboard as surface for sliding offered the maximum friction followed by galvanised iron, aluminium and glass.
- 3) The average length, width, thickness of raw cashew nuts at 8.46% moisture content was 31.00, 22.86 and 16.91 mm respectively, while the corresponding values of kernels were 24.67, 12.99 and 12.06 mm. About 52% of the nuts had length of between 30-35mm, whereas 11.5% and 36.5% of nuts categorized under >35mm and <30mm respectively. The average unit mass of the nut and kernel was 5.96 and 1.89 g respectively.
- 4) The average sphericity of raw cashew nut and kernel at moisture content of 8.46% db were 0.74 and 0.63 respectively. Mass of 100 nuts of raw nut varied between 610.6g to 735.1 g and it increased linearly with increased moisture content.
- 5) The porosity increased from 48.03 to 52.33%, while the bulk density decreased from 624.2kg/m³ to 591.9 kg/m³ as the moisture content increased from 3.15% to 20.06% db. The true density of nuts followed a linear correlation with moisture content. It increased from 1.20g/cc to 1.24g/cc with increase in moisture from 3.15% to 20.06% db.
- 6) The static co-efficient of friction for nuts increased linearly with moisture content irrespective of surface employed, namely, glass (0.19 to 0.25), aluminium (0.25 to 0.30), galvanised iron (0.25 to 0.30) and cardboard (0.25-0.31).
- 7) The equilibrium moisture content of raw cashew nuts increased with the relative humidity and exhibited desorption isotherm up to 74.12% but at 81.33% it followed adsorption isotherm. Mould growth and deterioration occurred after 28 days at 81.33% after the commencement of experiment.

- 8) Gravity separator was designed taking into consideration of the variation in kinetic energy while in movement along the slope. The trials conducted with three different end slopes i.e., 4, 7, 11 revealed that the separation efficiency was not up to the mark primarily due to similar smoothness of raw nut irrespective of its quality.
- 9) A sieve separator was developed on the basis of the relationship between the sphericity and the nut size. As the curvature of side varied with size of the nut, the minor axis dimension was taken into consideration for sieve design. Due to the irregular shape, nut had different orientation while moving towards sieve hole resulting in clogging which lowered the separation efficiency.
- 10) In view of lower separation efficiency in gravity and sieve separator, a rotary grader with four different sieve segments which can be operated both manually and through electrical motor is suggested to grade the raw nuts based on size.

Publications :

- 1) Balasubramanian, D. 1998. Equilibrium moisture content of cashew nut. *Cashew Bulletin*. **35**(2):2-3.
- 2) Balasubramanian, D. 2001. Physical properties of raw cashew nut. *J. Agric. Engg. Res.* **78**(3):291-297.

1999

25. **Project Title** : Propagation and rejuvenation studies in cashew - studies on top working
2.1
Ref: NRCC Ann.Rep. 1998-99
- Duration** : 1990-1999
- Project Team** : K.R.M. Swamy (1990-99), N. Bakthavatsalam (1990-92), P.S. Bhat (1993-94) and T.N. Raviprasad (1995-99) and M.G. Nayak (1994-95)

Objectives :

- i) To compare economics of top working with replanting of cashew.
- ii) To conduct on-farm trials on top working.
- iii) To replace a variety in scion bank by adopting top working technology.

Summary of Results :

- 1) Top working is economical compared to replanting, if CSRFB is managed effectively.
- 2) The technology of rejuvenation being simple, can be adopted by small and marginal farmers with training and proper technical know-how.
- 3) Top working technology is suitable for homestead gardens / small holdings where the farmer would be able to take intensive care of the top worked trees.

- 4) Morality of the successfully top worked trees was encountered due to CSRB infestation inspite of giving regular prophylactic treatments. The mortality was more in plots which were surrounded by the CSRB infested plantations and in the older trees.
- 5) Cashew trees of less than 10 year old are desirable for top working as the mortality due to CSRB infestation, is less.
- 6) This technology is not suitable for areas where CSRB infestation is high, particularly for cashew development corporation plantations.
- 7) This technology is useful in replacing a existing variety in the scion bank with a desired variety. Since the spacing adopted is generally 4m x 4m, (closer spacing, compact area) in scion bank, it is easy to manage the top worked plants. The dead plants need to be uprooted and replanted with grafts.

Publications :

Swamy, K.R.M. 1995. Top working of cashew (*Anacardium occidentale* L.) in Goa and Maharashtra states - a case study. *The Cashew.*, 9(2):12-17.

26. **Project Title** : Collection of cashew (*A. occidentale* L.) germplasm from forest plantation from Karnataka.
Ad-hoc Scheme
Ref: NRCC Ann.Rep. 1998-99.
- Duration** : 1996-1999
- Project Team** : K.R.M. Swamy (1996-99), Thoyajaksha (1996-97), N.S. Shankararaja (1998 April - 1998 May).

Objectives :

- i) To survey Forest / Karnataka Cashew Development Corporation plantations for identifying the elite and diverse germplasm.
- ii) To collect the scions from identified cashew trees and produce their clones.
- iii) To conserve the clonal accessions in the National Cashew Gene Bank.

Summary of Results :

- 1) A total of 42 accessions were collected from forest / KCDC plantations in Karnataka during 1996-1999.
- 2) Of the 42 accessions, 14 accessions had 4-5 desirable characters such as cluster bearing habit (> 6 nuts/panicle), medium to bold nut size (6 to 9 g), high shelling percentage (28 to 30) and high yield.
- 3) Some of these collections could be efficient root stocks in utilizing native fertility, as forest plantations seldom receive manures / fertilizers.

- 4) Five accessions had distinct characters such as big sized flowers (Kodippady-1, Sablady-1), long apple shape (Suvarmale-1), round shaped nuts (Kodimbady-1), and rare leaf shape (Kodimbady-2).
- 5) As these collections are made from forest plantations which are maintained under neglected conditions, some of the collections could be suitable for low input conditions / waste lands.

Publications :

Nil

2000

27. **Project Title** : Tissue culture studies in cashew for micropropagation and somaclonal variation.
1.3
Ref: NRCC Ann.Rep. 1999-2000
- Duration** : 1990-2000
- Project Team** : Thimmappaiah (1990-2000) and Shirly Raichal Anil (1994-2000)

Objectives :

- i) To standardize micropropagation techniques in cashew.
- ii) To induce and exploit somaclonal variations for breeding purposes.

Summary of Results :

For initiation and establishment of nodal cultures Murashige and Skoog's (1962) (MS) medium modified to contain 3/4 strength salts, 3% sucrose and 1g/l activated charcoal (AC) solidified with 0.8% agar was found ideal. Axillary shoot-bud proliferation (1-13 shoot buds/explant) was obtained when nodal cultures established were re-cultured on the above basal medium with 1 g/l PVP-360, 2.25 g/l phytigel containing thidiazuron (TDZ) alone and in combination with other plant growth regulators (BAP, NAA and IBA). Multiple shoots after subculturing on hormone free medium viz., Raj Bhansali's medium (1990) resulted in elongation of shoots. Microshoots thus generated showed rooting by both *ex vitro* method and *in vitro* methods. However, rooting was maximum (50-80%) when cultured on half MS medium containing NAA alone (5 mg/l) or NAA+IBA at 2.5 mg/l each. Rooted plantlets were successfully hardened both *in vitro* and *ex vitro* (pot stage) conditions and field planted. In field, micro propagated plants were found to be vigorous, strong in lateral root-system and showed normal flowering and fruiting behaviour. In contrast to seedling explants, nodal explants established from young cashew grafts and field grown trees were found to be highly prone to contamination and showed reduced response. It was dependent on season, type and source of explant. Half- MS medium supplemented with glutamine (400 mg/l), AC (2 g/l), phytigel

(2.25g/l) was found suitable for initiation. The above basal medium containing PVP-360 (1 g/l) instead of AC and in presence of TDZ alone or in combination with BAP, GA₃ (0.5-2 mg/l) and IBA (0.1 mg/l) induced multiple shoot buds (1-9 buds/plant). Callus could be induced in dark from internode, leaf and cotyledonary explants on half- MS medium containing 2,4-D with BAP. Only leaf and cotyledonary callus was regenerative.

Publications :

- 1) Thimmappaiah and Shirly Raichal Samuel. 1996. Micropropagation studies in cashew (*Anacardium occidentale* L.). National Symp. Hort. Biotech. Bangalore, Oct. 28-30. Souvenir Abst.No.11-10, p-5.
- 2) Thimmappaiah and Shirly Raichal Anil. 1999. In vitro regeneration of cashew (*Anacardium occidentale* L.). *Indian J. Exp. Biol.* **37**:384-390.
- 3) Thimmappaiah and Shirly Raichal Anil. 2000. Micropropagation in mature tree of cashew. In. *Recent Advances in Plantation Crops* (Eds - Muralidharan, N. and Rajkumar, R.). Allied Publications Ltd., New Delhi. pp.45-48.
- 4) Shirly Raichal Anil, Thimmappaiah and Rohini Iyer. 2000. Vesicular Arbuscular Mycorrhizal association in cashew (*Anacardium occidentale* L.) In. *Recent Advances in Plantation Crops* (Eds - Muralidharan, N. and Rajkumar, R.). Allied Publications Ltd., New Delhi. pp.390-392.
- 5) Thimmappaiah, Shirly Raichal Anil and R.D. Iyer. 2001. Cashew. In: *Biotechnology of Horticultural Crops* (Eds. V.A. Parthasarathy, et.al.) NP Sales Pvt. Ltd. Kolkata. Vol.1. pp. 609-629.

2001

28. **Project Title** : Root stock scion interaction in cashew.
2.9
Ref: NRCC Ann.Rep. 2000-2001

Duration : 1998-2001

Project Team : K.R.M. Swamy and M.G. Nayak

Objectives :

- i) To study the influence of semitall root stocks on growth of scion variety.
- ii) To identify a rootstock which can impart its semitall growth habit to the scion variety.
- iii) To study the effect of plant growth retardants such as paclobutarzol on regulation of tree size / canopy growth to induce dwarfing.

Summary of Results :

A. Root stock studies

- 1) Compared with the tall root stock (Selection-1), the *in situ* grafts of

Selection-1 on tall (Selection-1) and semitall (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) root stocks were tall and vigorous like Selection-1. Trunk girth and canopy spread of in situ grafts were comparable with the tall root stock (Selection-1).

- 2) Irrespective of the root stocks, *in situ* grafts of the tall scion variety (Selection-1) were tall and vigorous.
- 3) Semitall root stocks (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) evaluated did not influence the growth of in situ grafts of tall growing scion variety.

B. Induction of dwarfing through chemical intervention:

- 1) Soil application of paclobutrazol @ 6-8 g ai/plant at preflushing stage (September) was found to be effective in regulating the tree and canopy growth in cashew.
- 2) Foliar application of paclobutrazol at concentration ranging from 1 to 400 ppm during pre-flushing (September) or post flushing (November) stage was not effective in regulating the tree growth and canopy growth.

Publications :

Nil

29. **Project Title** : Functional properties of defatted cashew kernel meal.
4.4
Ref: NRCC Ann.Rep. 2000-2001
- Duration** : 1998-2001
- Project Team** : K.V. Nagaraja

Objectives :

To generate data on functional properties of cashew kernel baby bits for developing value added products.

Summary of Results :

Functional properties of defatted cashew kernel flour could be improved by mixing with defatted flour soybean in 1:1 ratio for its water absorption capacity and emulsification capacity. Stable foam over wide pH range from 3 to 9 could be produced with defatted cashew kernel flour. Defatted cashew kernel flour with low gelation concentration of 6%, could be used in developing products where gelling is required. Organoleptically acceptable spread could be prepared from cashew kernel baby bits. Cashew kernel spread could be stored at low temperature (<0°C and 6 to 10°C) for a period of six months without quality deterioration. Oil extracted from cashew kernel baby bits after

refining could be stored at ambient temperature upto six months without affecting the quality.

Publications :

Nagaraja K.V. 2001. Functional properties of defatted cashew kernel flour. *J. Food. Sci and Technol* **38** : 319-323.

30. **Project Title** : Design development and performance evaluation of improved cashew nut sheller
4.5
Ref: NRCC Ann.Rep. 2001-2002

Duration : 1998 - 2001

Project Team : D.Balasubramanian

Objectives :

To design, develop and evaluate the performance of improved cashew nut sheller

Summary of Results :

The improved shelling unit for cashew nut works on the basic principle of cutting and shearing. In this method, single operation enables the nut to get split between two horizontally mounted blades specially shaped to suit the contour of the raw nut. The major parts of sheller are classified into i) Nut holding assembly, ii) Nut splitting mechanism and iii) Drive assembly. The nut holding assembly is made to slit the concave or notched portion of the cashew nut. It comprises of sliding arm, guiding rod, compression springs and front and back row supports. The compression spring ensures the sliding arm to regain its original position after releasing the force applied.

Nut splitting mechanism consists of twin blade arm, vertical disc and disc actuating assembly. The radial movement of disk makes the twin blades to move apart due to the hinge and eccentric joint. This assembly converts the linear movement to radial movement. The linkage assembly has two cams, one of which is fitted to the mid point transfers motion to nut holding arm. The second cam is fixed at the extreme point of the driving shaft in order to actuate split blades. The cam at centre of shaft is designed in such a way that it gently pushes the sliding arm until the attached blade penetrate and slips not allowing the nut holder assembly to return back. Exactly at the slipping point onwards the split cam pushes the sliding rod in order to actuate the disc. This aid in opening twin blade and split the nut.

The average operational capacity of improved cashew nut sheller is 9.3 Kg /h. The average qualitative efficiency of the unit in terms of wholes and broken is 9.84. The constant movement of blades and splitting angle of twin blades enable the penetration of blades upto inner edge of shell. This has protected the kernel damage to greater

extent. The whole kernel yield at shelling level is one of the factors in economic efficiency. The statistical analysis proved irrespective of the operators, the qualitative efficiency remained unchanged. The overall quantitative efficiency is 87.52%. Increasing trend in all the processing parameters viz., operational capacity, w/b ratio and shelling efficiency, was observed when allowed to shell the nuts continuously for long period. The sitting posture reduced the operator's drudgery.

Publications :

Nil

31. **Project Title** : Network programme on collection of cashew germplasm from east coast and west coast regions of India
Adhoc scheme
Ref: NRCC Ann.Rep. 2001-2002
- Duration** : 1997-2001
- Project Team** : MG Bhat, KRM Swamy, EVV Bhaskara Rao
Shruthakeerthiraja (1997-98), U. Vishu Kumar (1998-2000),
CH Yajnesh (1998-2001) and D. Manjunath (2000-2001)

Objectives :

- i) Surveying the cashew plantations of seedling origin in five states, namely, Tamil Nadu, Andhra Pradesh, Orissa, Kerala and Maharashtra for identifying high yielding, elite and diverse types.
- ii) Conservation of identified trees in the National Cashew Gene Bank (NCGB) / Regional Cashew Gene Banks (RCGBs).

Summary of Results :

- 1) A total of 52 accessions were collected from Kerala (21), Tamil Nadu (7), Andhra Pradesh (4), Maharashtra (16) and Orissa (4).
- 2) One set of collected accessions was conserved at NCGB in NRCC, Puttur and another set was conserved in RCGBs of respective collaborating centres.
- 3) Maximum number of desirable types was obtained from Kerala, followed by Maharashtra. Of the 52 accessions, 12 accessions had five or more desirable characters such as yield, nut weight, kernel weight, fruits/panicles and shelling percentage.

Publications :

Nil

32. **Project Title** : Varietal Improvement of Cashew
Evaluation of elite germplasm accessions and recommended varieties of cashew.(Part of the project)
Ref: NRCC. Ann. Rep.2001-2002.

Duration : 1986-2001

Project Team : MG Bhat, KRM Swamy and KV Nagaraja

Objectives :

- i) Evaluating the performance of a few elite cashew germplasm accessions for yield and other economic characters and identification of high yielding accessions with medium nut size types.
- ii) Evaluation of the performance of a few recommended cashew varieties for yield and other economic characters.

Summary of Results :

- 1) The germplasm accessions differed for yield and yield component characters. VTH 59/2 (13/5 Kodur) and VTH 539/2 (M 76/2) identified from this trial on evaluation of 14 germplasm accessions are recommended for utilizing in the crossing programme.
- 2) Large variation was observed among the 18 recommended varieties for most of the economic and other characters evaluated in two trials. Several individual cashew trees have been found with yield level of more than one ton per hectare in most of the varieties evaluated. Mixed flowering phase for longer duration may be desirable for achieving higher yield.
- 3) Cashew kernel and apple juice from recommended varieties have been characterised for biochemical composition. The varieties showed wide variation in the oil, proteins, sugars and starch contents. The oil content varied from 34.7% (NDR 2-1) to 47.4% (BPP-2). Proteins, sugars and starch content were analysed on defatted flour. Kernel protein content varied from 35.60% (NDR 2-1) to 65.82% (BPP6). Sugar content showed variation between 6.98% (VRI-1) and 16.19% (BPP-2). Starch content among different varied from 17.50% (BPP-6) to 25.70% (V-1).

Cashew apple juice from BPP-4 exhibited all the desirable characters such as low tannin, high sugar and high ascorbic acid content and low MCH.

Publications :

Nil

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