ISSN: 2581-3749 (online) Advanced Agricultural Research & Technology Journal ▪ Vol. IV ▪ Issue 1 ▪ JANUARY 2020

Coconut and Arecanut Production Protocol under Aberrant Climate of Coastal Region

R. G. Khandekar[1]*, V. S. Desai[2], R. V. Dhopavkar[3], P. G. Borkar[3], P. M. Haldankar[4], S. Arulraj[5], Y. R. Parulekar[1], M. S. Gawankar[6], S. B. Thorat[1], N. V. Dalvi[1], M. M. Kulkarni[1], B. R. Salvi[1], P. C. Haldavnekar[6], C. D. Pawar[1], V. S. Pande[3], S. S. Gurav[3], A. A. Dademal[3], K. V. Malshe[7], G. D. Shirke[8], U. B. Pethe[3], R. R. Rathod[3], Y. S. Saitwal[6], K. G. Dhande[9], V. V. Aware[9] and U. V. Mahadkar[3]

[1]DBSKKV-College of Horticulture, Dapoli, Ratnagiri, Maharashtra - 415712 (India)
[2]DBSKKV-Regional Fruit Research Station, Vengurle, Sindhudurg, Maharashtra - 416516 (India)
[3]DBSKKV-College of Agriculture, Dapoli, Maharashtra - 415712 (India)
[4]Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra - 415712 (India)
[5]ICAR-Indian Institute of Oil Palm Research, Pedavagi, Andhra Pradesh - 534475 (India)
[6]DBSKKV-College of Horticulture, Mulde, Sindhudurg, Maharashtra - 416520 (India)
[7]DBSKKV-Mango Research Sub-Station, Girye, Devgad, Sindhudurg, Maharashtra - 416806 (India)
[8]DBSKKV-Post Graduate Institute of Post Harvest Management, Killa-Roha, Raigad, Maharashtra - 402116 (India)
[9]DBSKKV-College of Agricultural Engineering and Technology, Dapoli, Ratnagiri, Maharashtra - 415712 (India)

Abstract

Coconut and arecanut are the components of most of the farm holdings in coastal India. The climatic fluctuations in coastal region affected the production cycle of coconut and arecanut causing remarkable loss to the farmers. To mitigate the adverse effect of climate change, various modern scientific technologies viz., variety, integrated nutrient and water management, multi-storeyed multispecies mixed cropping and appropriate crop protection are advocated. Among the various varieties, Philippines ordinary, Lakshadweep ordinary, T x D and Pratap can be rated as better stable varieties considering *copra* (dry coconut flesh) and oil yield. Arecanut variety Shriwardhanee produces very soft nuts with sweet kernel with high sugar content (2 to 3%). Application of vermicompost @ 50 kg palm^{-1} yr^{-1} was helpful to obtain stable yield in coconut. Nutmeg (*Myristica fragrans* Houtt.), cinnamon (*Cinnamomum verum* P. resl), banana (*Musa acuminata*), pineapple (*Ananus comosus* L.) in a cropping system proved to be highly remunerative for elevating the income level with sustainability.

Keywords: Coconut, arecanut, climatic fluctuations, production technology

Corresponding author: rgk.bskkv@rediffmail.com
Received Date: 28.10.2019 ; Accepted Date: 20.12.2019

Introduction

Coconut is an important plantation crop cultivated on the West Coast and East Coast of India in Kerala, Tamil Nadu, Karnataka, Maharashtra, Andra Pradesh, Odissa, West Bengal and Goa. Presently it is established on 20,92,000 ha area with 15,339 MT production. Importantly, it is a crop of small and marginal farmers since 98 percent of about five million coconut holdings in the country are present in less than two hectares Anonymous (2003). Arecanut on the other hand is highly profitable commercial plantation crop established on 4,72,000 ha mostly in Karnataka, Kerala, Assam, Maharashtra, West Bengal and Tamil Nadu with total production of 7.35 lakh t (Anonymous 2019). In Kerala, Goa, Maharashtra and Karnataka the coconut and arecanut based homestead gardens form back bone for the livelihood security of millions.

Konkan region is experiencing acute weather vagaries viz., unseasonal rains, delayed monsoon, prevalence of low temperature for prolonged period, prolonged dry spell during rainy season, heavy rainfall in short period which alter the production cycle of coconut and arecanut. Occurrence of drought as well as cyclones disturb the anchoring of the palm besides low yield due to accelerated fruit drop. The meta-analysis of past data have indicated the climate related impacts on plantation crops but it was difficult to desegregate confounding effects of technological and other interventions in impact of climate change on plantation crops (Nareshkumar 2005; Hebbar and Chaturvedi 2015). Droughts and cyclones severely

affect the coconut yield. The above disturbances have affected the production paradigm and farmers and they fetch severe economic losses. Investigations on various modern technologies like selection of variety, integrated nutrient and water management, multi-storeyed mixed cropping for sustainable production, growing intercrops and mixed crops for increasing profitability and appropriate crop protection have proved their potential to obtain sustainable yield from coconut and arecanut even under climatic fluctuations.

Coconut

Variety selection

Large number of improved varieties of coconut are available for planting. However, the variety selected for planting should necessarily bear high number of female flowers per spike which is controlled by additive as well as non-additive gene action (Maheshwarappa and Kumar 2014). Size and weight of nut had inverse correlation with nuts per palm. Varieties such as Philippines ordinary, Lakshadweep ordinary, T x D and Pratap could be rated as better stable varieties considering *copra* (dry coconut flesh) and oil yield. Greater trunk circumference, more number of closely-spaced short leaves with short petiole and few broad leaflets are the features of ideal foliage architecture in palm to ensure maximum coconut yield (Anonymous 2014b). The varieties must contribute greater yield with respect to nut, *copra* and oil. The development of improved varieties augmented the coconut plantation along the West Coast of Maharashtra and Goa (Table 1 and Figure 1). The demand for tender coconut is rapidly increasing. To cater the need, emphasis in future need

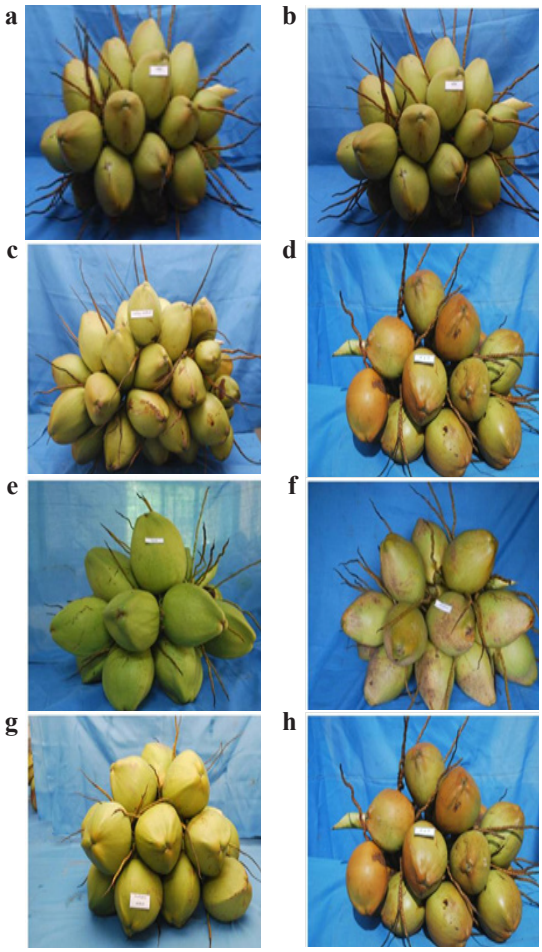

Fig. 1. Different varieties of coconut developed/recommended by DBSKKV, Dapoli: (a) Pratap – Improved variety, (b) Konkan Bhatye Coconut Hybrid-1, (c) Chandrakalpa, (d) Kera Sankara, (e) Kera Bastara, (f) Gauthami Ganga, (g) Kera Chandra, (h) Chandra Sankara.

Table 1. Coconut varieties released and recommended for commercial cultivation in Maharashtra

Variety	Year of release/ Recommendation	Parentage	Age at first flowering (years)	Nut yield palm^{-1} (No.)	*Copra* yield g palm^{-1}	Oil yield (%)	*Copra* yield (t ha^{-1})
Released Varieties							
Pratap	1987	Selection	6-7	140-145	120-160	68.00	3.48
Konkan Bhatye Coconut hybrid -1	2007	GBGD x ECT	4.5-5	120-122	160-169	67.10	3.40
Recommended Varieties							
Chandra Kalpa	1985	Selection	6-7	146-150	140-180	72	3.12
Kera Sankara	1989	Selection	4.5-5	135-140	170-190	68	3.78
Kera Chandra	1995	Selection	6-7	100-105	215-225	69	3.86
Chandra Sankara	2003	Selection	4.5-5	145-150	160-200	68	4.27
Kera Bastar	2007	Selection	6-7	116-120	169	67.0	3.18
Gouthami Ganga	2007	Selection	4.5-5	96	230	64.0	1.80

Source: Anonymous 2014b, Anonymous 2008, Maheshwarappa and Kumar 2014, Anonymous 2010b, Niral *et al.* 2014, Patil *et al.* 1991, Nagwekar *et al.* 2002, Patil *et al.* 2000, Anonymous 2007, Patil *et al.* 1993, Subramanian *et al.* 2009.

to be given on dwarf varieties viz. Chaughat, Orange Dwarf, Gangabondam, Green Dwarf, Kalpasree, Kalpa Jyothi and Kalpa surya. The performance of these varieties is promising besides the benefit in harvesting.

Integrated nutrient and water management

Integrated nutrient management, integrated water management, and fertigation play a critical role for obtaining adequate yield even under climatic fluctuations. In coconut large quantity of biomass is available which can be appropriately decomposed in the form of compost or vermicompost. Though it contains large quantity of fibre the earthworm species *Eudrilus eugeniae* efficiently convert coconut biomass into high quality vermicompost. Application of vermicompost at the rate of 50 kg palm^{-1} yr^{-1} was economical for stable yield in coconut (Maheshwarappa and Kumar 2014). A package of of 1000 g nitrogen, 500 g phosphorous and 1000 g of potash palm^{-1} yr^{-1} in three splits (June, October, and February) also help to obtain higher yields of coconut in sandy coastal soils (Maheshwarappa and Kumar 2014, Anonymous 2008).

Hybrid varieties of coconut possess a greater potential with respect to yield and yield contributing characters. A composition of 1000 g nitrogen, 500 g phosphorus and 2000 g potash proved to be effective to elevate higher yields in sandy soils of coastal region (Anonymous 2008). In addition to major nutrients, application of micronutrients viz., zinc (Zn), magnesium (Mg), manganese (Mn), copper (Cu), iron (Fe), molybdenum (Mo) and boron (B) increased the yield of coconut under coastal climatic conditions (Anonymous 2002, Nagwekar *et al.* 2002).

Though coconut thrives best under coastal conditions, the irrigation with only sea water had detrimental effects at any growth phase in newly planted plantation. The dilution of sea water with fresh water reduces the extent of primary stress injury but imposes the salt injury causing decrease in uptake of mineral element which results in poor growth of seedlings (Anonymous 2002, Patil *et al.* 2001). The drip irrigation with 30 L water palm^{-1} day^{-1} during the months of October to January and 40 L during February to May with six drippers placed at a distance of 1.25 m away from the bole in the sandy loam soils of coastal region are advantageous for adult coconut palm (Anonymous 2009, Anonymous 2005b, Nagwekar *et al.* 2006). Fertigation of 1 kg N, 0.5 kg P_2O_5 and 1 kg K_2O palm^{-1} year^{-1} in eight splits from October to May is profitable (Anonymous 2012, Thomas *et al.* 2014).

Table 2. Economics of Coconut based high density multispecies cropping system (Average of 5 years: 1999-2004).

Block	Total Cost ₹ ha^{-1}	Total Returns ₹	Net Profit ₹	B:C Ratio
Cinnamon	83,449	1,37,877	54,428	1.65
Nutmeg	86,417	1,79,995	93,578	2.08
Black Pepper	79,313	1,30,213	50,900	1.64
All spice	68,087	1,05,952	37,865	1.55
Clove	77,017	1,09,496	32,479	1.42
Garcinia	81,483	1,36,976	55,493	1.68
Control	55,207	81,194	25,987	1.47

Source: Anonymous 2014a, Anonymous 2008.

Coconut-based high density multispecies cropping system

Coconut-based cropping system involving cultivation of compatible crops offer considerable scope for not only increasing productivity per unit area, time and inputs by more efficient utilization of resources like sunlight, soil, water and labour but also provide multiple options for sustainability even under climate change (Bavappa and Jacab 1982). The option for raising annuals or perennials in the interspaces of coconut

Fig. 2. Coconut based cropping systems

Table 3. Biological control of coconut pests and diseases

Name of Pests/Diseases		Biological control
Pests	Rhinoceros beetle	Field release of Baculovirus inoculated adult rhinoceros beetle @ 15 ha^{-1} reduces the leaf and crown damage.
	Black headed caterpillar	Olfactory stimulation of the larval parasitoids, *Bracon brevicornis* and *Goniozus nephantidis*, with the excreta/faecal pellets of BHC, was also done under laboratory conditions 48-72 hours prior to release of the parasitoids which enhanced the parasitisation levels under field conditions.
	Red palm weevil	Economically feasible and Eco-friendly attractant pheromones lures (Ferrolure) developed for the monitoring and mass trapping of coconut red palm weevil.
		Setting up of attractant traps (mud post) containing sugarcane molasses 2½ litres + acetic acid 5 ml+ yeast 5g+ longitudinally split tender coconut stem/long of green petiole of leaves @30 numbers in one acre to trap adult red palm weevils in large numbers.
	Eriophyid mite	Spraying talc formulation of *Hirsutella thompsonii* (CPCRI isolate) during non rainy months@ 20g $palm^{-1}$: 3 sprays $year^{-1}$ during October/ November, January/February and April/May reduces the incidence of eriophyid mite damage significantly.
	Basal stem rot	Soil application of *Trichoderma viride* @ 250 g $palm^{-1}$ $year^{-1}$ along with neem cake @ 5 kg $palm^{-1}$ $year^{-1}$ followed by root feeding of 1 ml hezaconazole + 100 ml water $palm^{-1}$ thrice at quarterly intervals was effective in managing the basal stem rot.
Diseases	Leaf blight disease	Root feeding of Tridermorph 2 ml or Hexaconazole 2 ml or Carbendazim 2g + 100 ml of water $palm^{-1}$ thrice at quarterly intervals was effective in reducing the leaf blight. Application of *Pseudomonas fluorescens* talc formulation @ 200 g $palm^{-1}$ $year^{-1}$ was also effective.
		Root feeding of *P. fluorescens* culture suspension @ 25 ml $palm^{-1}$ at quarterly interval along with soil application of *P. fluorescens* talc formulation (50 g $palm^{-1}$ yr^{-1}) + Neem cake (5 kg $palm^{-1}$ yr^{-1}) was found to be the best against leaf blight disease.
		A microbial consortia containing the antagonists viz. *P. fluorescens* Pfl, *B. subtilis* (kambalapatti) and *T. viride* (TVl) was developed for the management of leaf blight.
	Root (wilt) disease	*Trichoderma viride* was found as an effective biocontrol agent against *Aspergillus flavus* in vitro.

Source: Anonymous 2014b.

and advantages thereof are well recognized (Nelliat 1973). The coconut plantation is most suitable for growing variety of the intercrops because the crown shape and length of coconut leaves necessitate a wider spacing. However, it does not fully utilize available basic requirements of crop production viz. soil, solar energy, water and nutrients (Dhanpal 2010). It was reported that 74% of roots produced by palm under good management do not go beyond 2 m whereas, 82% of the roots were confined to 31-120 cm depth of soil

(Kushwah *et al.* 1973). The Venetian structure of coconut crown and orientation of leaves allow higher than 6700 Lux incident solar radiation to pass through the canopy and fall on the ground (Nair 1979). All these favourable factors permit to select suitable intercrops/mix crops or favourable perennial crops for growing in interspace in the coconut plantation. Integrated cropping system in coconut plantation with nutmeg (*Myristica fragrans* Houtt.), cinnamon (*Cinnamomum verum* P. resl), banana (*Musa acuminata*), pineapple (*Ananus comosus* L.) and a poultry unit have shown promising (Anonymous 2005a). Intercropping of turmeric (*Curcuma longa* L.), banana, pineapple and tapioca (*Manihot esculanta*) was remunerative in coconut plantation under coastal conditions (Nagwekar *et al.* 2010). The tree spices when mixed planted increased the average yield of coconut palm from 23 to 96 per cent (Nagwekar *et al.* 2002). Nutmeg with coconut together provided a net return of ₹ 93,578 ha^{-1}. followed by Garcinia (₹ 55,493 ha^{-1}) and cinnamon (₹ 54,428 ha^{-1}). Coconut as a mono-crop recorded a net profit of ₹ 25,987 ha^{-1} (Table 2 and Figure 2). Noni (*Morinda citrifolia* L.) - a medicinal plant-can be a compatible, economical, and perennial mixed crop (Khandekar *et al.* 2014). Performance of arrowroot (*Maranta aurandinacea* L.) and lemongrass (*Cymbopogon flexuosus* stevd) as intercrops in coconut plantation was also satisfactory in coastal region (Anonymous 2010a).

The biomass productivity of coconut ranged from 3.4 to 5.1 t ha^{-1} and it ranged from 0.16 to 4.45 t ha^{-1} in different tree spices. The vermicomposting productivity of coconut ranged between 2 to 3 t ha^{-1} whereas it was 0.048 to 1.5 t ha^{-1} in different spice crops. Nutrient recycling rate of 43.62 kg N, 9.64 kg P, 30.13 kg K, 21.81 kg Ca and 16.56 kg Mg per ha in coconut can be achieved through proper utilization of available biomass. Substitution of inorganic fertilizers of 33 % N, 3.67 % P_2O_5 and 22.96 % K_2O in coconut and 20.40 % N, 2.7 % P_2O_5 and 20.67 % K_2O in tree spices was achieved by organic recycling (Anonymous 2003). Under coastal conditions, cultivation of cucurbitaceous vegetables in kharif such as ridge gourd, cucumber, snake gourd and bitter gourd in coconut plantation provide supplementary income (Nagwekar *et al.* 1997). Cultivation of Dolichos bean or tomato as intercrop in coconut plantation area was the most remunerative on the basis of economic returns obtained $manday^{-1}$ ha^{-1} (Patil *et al.* 1995). The cultivation of chilli (cv. Jwala or Konkan Kirti) as an intercrop was beneficial due to its higher yield and net returns (Maheshwarappa and Kumar 2014).

Appropriate Crop Protection

The climatic disturbances aggravate various pest and diseases affecting coconut. Survey on the occurrence of coconut diseases revealed that stem bleeding, besal stem rot, leaf blight, bud rot and root (wilt) diseases are recorded in Kerala and Tamil Nadu. The root wilt disease was noticed from 1 to 32.1 per cent in districts of Tamil Nadu bordering the Kerala state. Rhinoceros beetle, Black headed caterpillar, Red Palm weevil and Eriophyid mite are important damaging pests to coconut plantation found in all coconut growing states in India (Anonymous 2014b). The biological controls provide best means to manage the coconut pest and disease (Table 3).

Arecanut

Varietal selection

The arecanut variety possessing premium quality fetch best rates in market. In western parts of coastal India Shriwardhanee variety produces nuts which are very soft and sweet kernel with high sugar content (2 to 3%). Besides it is high yielding (8.11 kg $palm^{-1}year^{-1}$) with better nut weight (green - 34.34 g, kernel - 7.12 g). Its cultivation as both sole crop as well as mixed crop proved to be highly economical. Many other varieties also perform well under coastal belt (Table 4). Considering the climatic fluctuations, a mixed population of varieties carries advantage.

Appropriate planting material

Establishment of commercial plantation under climate change depends upon planting material. Well grown, vigorous seedling of arecanut is essential for the purpose. Seed storage in plastic bags (88.13%) moist sawdust (86.25%) and moist sphagnum moss (85.00%) help to improve seed germination. (Anonymous 2011). Soaking of areca seeds in gibberelic acid (GA) solution (100 ppm) for 24 hrs before sowing endure better height and girth of seeding (Niral *et al.* 2014). Bold seeds (weight more than 21 g) effected better germination and vigorous seedling (Nagwekar *et al*. 1998).

Integrated Nutrient and water management

Use of 15-20 kg FYM or compost or green manure, 150 g N, 75 g P_2O_5 and 150 g K_2O $palm^{-1}$ yr^{-1} elevate the yield under coastal conditions. Full doses of FYM and phosphorus should be applied once in a year in the month of June or October, along with half of the doses of nitrogen and potash. The remaining dose of the nitrogen and potash may be applied in the month of October or

January every year (Anonymous 2002). Micronutrients play a pivotal role in the growth and development of arecanut. Application of 600 g micronutrient mix (Bo -1%, Zn-5%, Mn - 1%, Fe - 2%, Cu - 0.5%) along with the recommended doses of fertilizers, improved the nut yield of arecanut appreciably (Anonymous 2014a; Dademal *et al*. 2014).

Table 4. Yield and nut characteristics of promising Arecanut cultivar under coastal region

Cultivar	Growth habit	Shape and size	Dry nut yield (kg plant^{-1} ha^{-1})	Recommended for
South kanara	Tall	Round bold	2.00	Coastal Karnataka, Kerala
Mangala	Semi tall	Round small	3.00	Coastal Karnataka, Kerala
Sumangala	Tall	Ovel, medium	3.20	Karnataka, Kerala
Sreemangala	Tall	Round, bold	3.18	Karnataka, Kerala
Mohitnagar	Tall	Round, medium	3.67	West Bengal, Karnataka, Kerala

Source: Anada and Thampan (1999)

Arecanut is very sensitive to moisture stress resulting into heavy fruit drop, leaf drying and death of plants and require consistent irrigation. The palms should be irrigated at an interval of 6-7 days in winter and 3-4 days in summer in flood system; irrigation through drip saves about 30 per cent water with additional benefit of saving labour cost (Anonymous 2002).

Arecanut-based high density multispecies cropping system

Arecanut plantation is suitable for growing various intercrops due to its straight, upright crown shape and leaf orientation. Intercropping of banana in arecanut plantation contributed maximum economic returns than sole crop under coastal conditions of Maharashtra (Anonymous 2002).

Table 5. Disease management schedule for arecanut

Name of Disease	Control measures
Koleroga	• Spray the areca palms with Bordeaux mixture (1%), twice or thrice in rainy season spraying with Carbonyl 50 WDP (0.1%) in these traps at an interval of 2 months. • Root feeding technique, comprised of selection of two active feeder roots/ palm and giving a slanting cut to the roots followed by application of Fosetyl –AL (80%) solution (0.3%) through two polythene bags containing the solution (100 ml in each bag) of the fungicide tied to the feeding roots. First dose of the fungicide be given before the onset of monsoon followed by two more applications in the similar manner at an interval of 21 days. • Application of 111 urea plus suphala briquettes or 76 Konkan Annapurna briquettes, amended with Fosetyl –AL (0.3%) per palm in the last week of May, by digging 15-20 cm deep holes at a distance of 1 meter from trunk and placing the briquettes with a briquette applicator followed by two more applications in the similar way. at an internal of 21-30 days.
Band Disease	• Provide proper drainage by digging trenches to avoid water stagnation in the plantation. • Application of 15-20 kg FYM/compost/ green manure palm^{-1} year^{-1}, use of RDF viz. 150g N, 75 g phosphorus, 150 g potash adult palm^{-1} yr^{-1}. • Irrigate the palms at an interval of 6 – 7 days in winter and 3 – 4 days in summer.
Anabe or foot rot or Ganoderma Disease	• Manage the disease by drenching with 10 L solution of either Bordeaux mixture (2%) or Carbendazim (0.1%) or mercuric chloride (0.1%) in the root zone of each infected palm in the early stages of disease development. The drenching should be repeated two or three times at an interval of 21 to 30 days after the first drenching.
Nut cracking	• As and when the problem arises, spray borax solution (2 g L^{-1}) on the bunches or apply boron (4 kg ha^{-1}) through soil.

Source: Anonymous 2002, Anonymous 2012, Anonymous 2011.

Intercropping of elephant foot yam (*Amorphophylus companulatus*) /ginger (*Zinziber officinalis*) / turmeric (*Curcuma longa*) crops is highly productive and profitable in coastal region (Anonymous 2016).

Appropriate Crop Protection

Several diseases affect arecanut palm causing considerable economic losses also gets serious under konkan agroclimatc conditions. The important diseases are fruit rot or Koleroga or mahali and Anabe disease or Hidimundige caused by Ganoderma (Sampathkumar and Saraswathy 1964). These diseases can be effectively managed by following appropriate plant protection schedule (Table 5).

Conclusions

Coconut and arecanut are important irrigated plantation crops in coastal region. The climatic vagaries experienced in coastal climate affect the growth and yield of these crops which cause severe economic loss to the farmers. Adoption of various mitigation technologies viz. varietal selection, integrated nutrient management, multistoried cropping system for sustainable production and appropriate plant protection measures as discussed in this paper can help sustaining the production of these two important plantation crops even under the changing climatic conditions.

References

Ananda K. S. and Thampan C. 1999. Promising cultivars and improved varieties of arecanut (*Areca catechu* L.). Ind. J. Arecanut, Spices, Medicinal Plants. 1: 24-28.

Anonymous 2002. Research Recommendations in Horticulture. A Research bulletin number 40 jointly published by Department of Horticulture, MPKV, Rahuri and Directorate of Horticulture Govt. of Maharashtra, Pune. 1 - 131.

Anonymous 2003. A final report of integrated management of palms based cropping/farming system for sustained productivity under coastal eco system. Regional Coconut Research Station, Bhatye, Ratnagiri, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India. 93 - 95.

Anonymous 2005a. A final report of coconut based high density multi-species cropping system. Regional coconut research station, Bhatye, Ratnagiri, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India, 8-9.

Anonymous 2005b. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at M.A.U. Parbhani. 28.

Anonymous 2007. Release proposal of GBGD x ECT coconut hybrid. Regional Coconut Research Station, Bhatye, Ratnagiri, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India. 1 to 10.

Anonymous 2008. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at P.D.K.V., Akola. 19, 27, 38.

Anonymous 2009. Price policy for copra 2018 season, Commission of Agricultural cost and prices, ministry of agriculture and farmers welfare, Govt. of India. Pp-5.

Anonymous 2010a. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at DBSKKV, Dapoli. 51-52.

Anonymous 2010b. Research Recommendation 2004-2009. A Research bulletin published by Dr. BSKKV, Dapoli. 1-33.

Anonymous 2011. Calender for Arecanut, Technical Bulletin, Central Plantation Crop Research Institute, Regional Station, Vittal, Karnataka. 33.

Anonymous 2012. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at M.P.K.V, Rahuri. 28.

Anonymous 2014a. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at DBSKKV., Dapoli. 6 and 21.

Anonymous 2014b. R.C.R.S., Bhatye – Research at a glance. A Technical bulletin AICRP on Palms, Regional Coconut Research Station, Bhatye, Ratnagiri, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India, 93 - 95.

Anonymous 2016. Proceedings of Maharashtra Agril. Universities Joint Krishi Research and Development meeting held at Akola.

Anonymous 2019. Directorate of Arecanut and Spices Development, Ministry of Agriculture, Govt. of India.

Bavappa K. V. A. and Jacab V. J. 1982. High density multi-species cropping. a new approach to small scale farming in the tropics. World Crops. 34: 47 – 50.

Dademal A. A., Khandekar R. G., Kasture M. C., Malshe K. V, and Haldankar P. M. 2014. Studies on effect of micronutrient complex on yield of arecanut. A paper presented at International Symposium on Plantation Crops at Kozhikode, Kerala, India on 10-12 Dec. 2014, 72.

Dhanpal R. 2010. Achiveing higher resources use efficiency and productivity in coconut through drip fertigation. A paper presented at International Conference Coconut biodiversity for Prosperity, organized at CPCRI, Kasargod, Kerala. 25-28.

Hebbar K. B. and Chaturvedi V. K. 2015. Impact and adaptation strategies of coconut to climate change In Proceeding of Kerala Environmental Congress, Centre for Environment and Development, Thiruananthapuram 73-78 pp.

Khandekar R. G., Nagwekar D. D., Maheswarappa H. P., Sawant V. S., Gurav S. S. and Haldankar P. M. 2014. Performance of *Morinda citrifolia* as mixed crop in coconut under Konkan region of Maharashtra. A paper presented at National conference on Sustainability of Coconut, Arecanut and Cocoa Farming Technology Advances and Way Forward held at CPCRI, Kasaragod, Kerala, India. 64..

Kushwah B. L., Neliat E. V., Markose V. T. and Sunny A. I. 1973. Rooting pattern of coconut. Indian J. Agron. 18: 71-74.

Maheshwarappa H. P. and Kumar R. 2014. Research accomplishment of AICRP on Palms. Technical bulletin no. 85 of All India Co-ordinated Research Project on Palms, CPCRI Kasargod, Kerala.,

1972-2014, 35-36.

Nagwekar D. D., Desai V. S., Sawant V. S., Haldankar P. M., Joshi G. D. and More T. A. 2006. Effect of drip irrigation on yield of coconut (*Cocos nucifera* L.) in sandy soil of Konkan region of Maharashtra (India). J. Plantation Crop. 34: 344-346.

Nagwekar D. D., Joshi G. D. and Magdum M. B. 2002. Effect of ormichem micronutrient on coconut yield Cv W.C.T. A paper presented at the seminar Plantation Crops Res. and Dev. in the New Millennium. 378-379.

Nagwekar D. D., Sawant V. S., Joshi G. D., Jambhale N. D. and Khan H. H. 2002. Performance of coconut hybrids under Konkan conditions of Maharashtra. Paper presented at Plantation Crops Symposium 15, 476 – 480.

Nagwekar D. D., Desai V. S., Sawant V. S., Haldankar P. M., Arulraj S. and Jadhav B. B. 2010. Intercropping with fruits and annual spices in coconut under Konkan condition of Maharashtra. A paper presented in International Conference Coconut Biodiversity for Prosperity, organized at CPCRI, Kasargod, Kerala.

Nagwekar D. D., Haldankar P. M., Rajput J. C. and Gunjate R. T. 1998. Longevity of areca seednuts as influenced by storage media and storage period. Indian Coconut J. 63-65.

Nagwekar D. D., Haldankar P. M., Rajput J. C., Magdum M. B. 2002. Studies on chemical characteristics of arecanut cultivar Shrivardhan local. J. Arecanut Spices Aromatic Crops. 11: 60-62.

Nagwekar D. D., Haldankar P. M., Desai A. G., Gunjate R. T. and Rajput R. C. 1997. Performance of rainfed vegetables as intercrops in coconut plantation. J. Plantation Crops. 25: 209-211.

Nair P. K. R. 1979. Intensive multiple cropping with coconut in India: Principles, Programmes, Prospects. Verlog Paul Parcy Berlin and Hamburg. Adv. Agron. Crop Sci. No. 6, 147 pp.

Naresh Kumar S. 2005. Variability in content and composition of fatty acids in coconut oil due to genetic and environmental factors. AP Cell funded project final report submitted to ICAR, New Delhi.

Nelliat E. V. 1973. Multiple cropping or multistoried cropping in plantation crops J. of Plant. Crops 1 (suppli). 204.

Niral Y., Augustine J. B., Samsudeen K., Thomas R. J. and Thomas G. V. 2014. Coconut Varieties and Hybrids. A technical bulletin no.87 published by CPCRI, Kasaragod, Kerala, India. 1-35.

Patil J. L., Haldankar P. M., Jamdagni B. M. and Rethinum P. 1991. Stability of nut yield in coconut. J. Plantation Crops. 19: 37-40.

Patil J. L., Haldankar P. M., Jamadagni B. M. and Salvi M. J. 1993. Inflorescence characters and yield in coconut. J. Maharashtra Agri. Univ. 18: 303-304.

Patil J. L., Haldankar P. M., Jamadagni B. M. and Salvi M. J. 1993. Variability and correlation studies for nut characters in coconut. J. Maharashtra Agri. Univ. 18: 361-364.

Patil J. L., Haldankar P. M., Jamdagni B. M. and Rethinum P. 2000. Foliar attributes in relation to nut yield in coconut (*Cocos nucifera* L.). South Indian Horti. 46: 303-308.

Patil J. L., Haldankar P. M., Rangwala A. D. and Jamdagni B. M. 2001. Effect of different irrigation with sea water on survival and growth of coconut (*Cocos nucifera* L.). South Indian Hort. 46: 361-363.

Patil J. L., Haldankar P. M. and Jamdagni B. M. 1995. Intercropping of vegetable in coconut garden. J. Plantation Crops. 19: 167-169.

Sampath Kumar S. N. and Saraswathy N. 1964. Advances in Horticulture. Published at Malhotra publication House, New Delhi. 10, pp- 939-967.

Subramanian P., Dhanpal R., Palaniswami C., Maheswarppa H. P., Gupta A. and Thomas G. V. 2009. Coastal sandy soil management for higher coconut productivity. A technical bulletin of All India Co-ordinated Research Project on Palms, CPCRI Kasargod, Kerala.1 – 19.

Thomas G. V., Jerard B. A., Krishna Kumar V., Chandran K. P., Muralikrishna H. and Gorge J. 2014. A Decade of Growth and Achievements of CPCRI. 2005-2014. A technical bulletin no. 88 of CPCRI, Kasargod, Kerala.107.