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Genetic divergence assessment in proso millet (*panicum milliaceum*)

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Department of Millets, Tamil Nadu Agricultural University (TNAU), Coimbatore.

Keywords:

Proso Millet
Genetic Diversity
Yield

Abstract

An investigation was undertaken to determine the extent of genetic diversity present among 52 proso millet genotypes using D^2 statistic. Cluster analysis grouped 52 germplasm into six clusters based on the degree of divergence between the genotypes. Maximum number of 27 and 17 genotypes were grouped under cluster I and IV, respectively, while clusters III had three genotypes and clusters II and V consisting of 3 genotypes each and cluster VI had single genotype. Maximum inter cluster was observed between cluster V and VI (30.96) followed by cluster II and VI (28.47). The greater the distance between the two clusters indicates wider the genetic diversity between genotypes. Hence, the genotypes in cluster V viz., CO 5, 23/1 had wider diversity with PCGP 49 in cluster VI and these lines may be utilized in further breeding programme for the exploitation of hybrid vigour. The intra cluster distance was maximum in cluster V (13.77) followed by cluster I (11.40) indicates hybridization involving genotypes within the same clusters may result in good cross combinations. Among the six traits studied, maximum contribution was made by single plant grain yield (49.55%) followed by days to 50 per cent flowering (26.62%) and number of productive tillers (17.04%). Hence, grain yield, days to 50% flowering and number of productive tillers together contribute 93.21% towards total divergence. Therefore, these characters may be given importance during hybridization programme.

Introduction

Proso millet, also called broomcorn and common millet, was domesticated in Neolithic China as early as 10,000 years ago. Proso millet was important in the diets of human across India prior to the introduction of wheat, barley and potatoes. At present it is consumed in significant quantities in India (where it is known as *pani varagu* in Tamil), Nepal, western Myanmar, Sri Lanka, Pakistan, and South East Asian countries. In order to ensure food security in the fragile ecosystem, it is important to trap the available genetic diversity among the germplasm to select the superior highly diverged lines may be used as the parents for the crop improvement programmes. Despite very meager work only carried out in proso millet germplasm to study the genetic divergence, further work is necessary to understand the genetic basis of phenotypic variation among different genotypes.

Materials and Methods

The experiment for the present study were conducted during summer, 2014 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The experimental material comprised of 52 proso millet entries and it was laid out in Randomised Block Design with two replications. The spacing between plant to plant, 7.5 cm and row to row, 22.5 cm was maintained. At the time of maturity

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three plants selected at random from each genotype and that were tagged in each replication. Observations on quantitative traits were recorded and the average of these five plants for each quantitative character was made to compute mean for further analysis. Observations were recorded for six quantitative traits *viz*., days to 50 % flowering, plant height, number of productive tillers per plant, length of peduncle, length of inflorescence and single plant grain yield. The quantitative measurement of genetic divergence among the genotypes was carried out by Mahalanobis D2 statistic (Rao, 1952).

Results and Discussion

The genotypes included in the study were from the different sources and were grouped into six clusters (Table 1). Cluster I was the largest with twenty seven genotypes followed by cluster IV with seventeen genotypes. The lowest single genotype was included in cluster VI. Clustering pattern under this study reveals that the proso millet showed considerable genetic diversity among themselves by occupying six different clusters. As statement by Murthy and Arunachalam (1966), this none parallelism may be due to genetic drift and intense natural and human selection for diverse adaptive gene complexes under different environments causing greater diversity among genotypes rather than their geographic distances.

The intra and inter cluster distance are presented in Table 2. Inter cluster distance was higher than intra cluster distance indicating wider genetic diversity among the genotypes. Cluster V (13.77) recorded the highest intra cluster distance followed by cluster I (11.40) and cluster IV (11.36). The inter cluster distance was maximum between cluster V and cluster VI (30.96) followed by cluster II and VI (28.47) indicating greater divergence belonging to these clusters. The crosses which involve parents from these more divergent clusters will yield relatively good amount of heterosis in F_1 and high frequency of transgressive segregants and genetic variability in subsequent generations. The minimum distance was

Table 1: Cluster composition of 52 proso millet germplasm

Cluster Number	No. of Accessions	Accession Number
I	27	PCGP 1, PCGP 2, PCGP 3, PCGP 4, PCGP 5, PCGP 6, PCGP 7, PCGP 8, PCGP 9, PCGP 10, PCGP 11, PCGP 12, PCGP 13, PCGP 14, PCGP 15, PCGP16, PCGP 17, PCGP 18, PCGP 19, PCGP 20, PCGP 21, PCGP 22, PCGP 23, PCGP 24, PCGP 25, PCGP 27, PCGP 50
II	2	PCGP 33, PCGP 41
III	3	PCGP 26, PCGP 30, PCGP 39
IV	17	PCGP 28, PCGP 29, PCGP 31, PCGP 32, PCGP 34, PCGP 35, PCGP 36, PCGP 37, PCGP 38, PCGP 40, PCGP 42, PCGP 43, PCGP 44, PCGP 45, PCGP 46, PCGP 47, PCGP 48
V	2	CO 5, 23/1
VI	1	PCGP 49

Table 2: Average intra (diagonal) and inter cluster distances in proso millet

Clusters	I	II	III	IV	V	VI
I	**11.40**	14.58	13.51	11.85	17.48	18.33
II		**1.47**	21.00	11.62	8.01	28.47
III			**10.89**	16.30	24.06	11.33
IV				**11.36**	14.53	21.96
V					**13.77**	30.96
VI						**0.00**

Table 3: Cluster mean values for six quantitative characters in proso millet

Clusters	Days to 50% Flowering	Plant Height	Number of Productive Tillers	Length of Peduncle	Length of Inflorescence	Single Plant Grain Yield
I	40.93	90.41	7.19	9.22	29.37	12.27
II	46.50	89.02	7.25	10.25	30.97	9.00
III	36.67	84.50	7.00	9.23	29.51	8.17
IV	42.97	88.64	7.21	9.02	30.52	12.83
V	47.25	88.43	3.75	9.93	33.27	11.74
VI	33.00	84.73	7.50	9.63	32.67	12.68

Table 4: Relative contribution of different characters towards divergence

S. No.	Characters	Number of first rank	Contribution (%)
1	Days to 50% flowering	353	26.62
2	Plant height	34	2.56
3	No. of productive tillers	226	17.04
4	Length of peduncle	43	3.24
5	Length of inflorescence	13	0.98
6	Single plant grain yield	657	49.55
	Total	1326	100

observed between clusters II and V (8.01) followed by cluster III and VI (11.33). The genotypes in these clusters are genetically very close and hence, hybridization among the varieties will not give fruitful result.

The cluster mean values are presented in Table 3. Among the characters, cluster V recorded the highest mean value for days to 50 percent flowering and length of inflorescence per plant. Cluster I had the lowest mean values for days to 50 percent flowering and the highest mean values for number of productive tillers per plant. Cluster IV had the highest mean values for single plant grain yield. None of the clusters contained genotypes with all the desirable traits which could be directly selected and utilized. All the minimum and maximum cluster mean values were distributed in relatively distant clusters. Based on the per se performance of the best genotypes within the clusters, they may be directly selected or may be used as potential parents in hybridization programme.

The contribution of each trait to total divergence is presented in table 4. Among the traits studied, single plant grain yield contributed maximum divergence (49.55%) followed by days to 50 percent flowering (26.62%) and number of productive tillers (17.04%). The minimum percentage of contribution was observed in length of inflorescence (0.98%) followed by plant height (2.56%) and length of peduncle (3.24%). The traits viz., grain yield, days to fifty percent flowering and number of productive tillers contributed 93.21 per cent towards total divergence. Hence, these characters should be given importance during hybridization and selection in the segregating population.

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Culture technology, management and economics of giant freshwater prawn *Macrobrachium rosenbergii*

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Keywords:
Macrobrachium Rosenbergii
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Culture Technology
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Abstract

The giant freshwater prawn, *Macrobrachium rosenbergii* is the largest prawn known in the world. It is also known as Scampi. Its farming is gaining popularity all over the world. It is the most preferred species for culture because it has fast growth rate, better meat quality, resistance to disease, omnivorous feeding habit, compatibility for polyculture with Indian and Chinese carps, adaptation to varying environmental conditions, easy breeding and good demand in domestic and international markets (Gupta 2006; New 1995, 2005).

Culture of prawn can be carried out in earthen ponds, cement cisterns, in pens or in cages. However, most of the operations are being carried out in earthen ponds. It can be reared in mono-culture or poly-culture with carps. The standard practices of scampi farming include site selection, pond construction, water source and quality, management practices, etc.

Selection of Site

The selected site should have the following major qualities: Supply of good quality, pollution free freshwater; Soil having a pH of more than 6.5 and good water retention capacity; and Warm climate for nearly 8 months (Temperature - > 25 ^{0}C)

Construction of Pond

Ponds should have an inlet and an outlet; Pond bottom should have a gradient slope towards the out let; Pond bunds should have a suitable slope (1 :2); Pond size - 0.2 -< 1.0 ha (0.2-0.5 ha); Depth - 2 m, Shape – Rectangular; and Soil - Clay loam, sandy loam.

Water Source and Quality

A permanent source of water is must before planning freshwater prawn farming. It includes tube well water, canal water, water from nearby river/ reservoir/lake, etc. Water used for culture should be free from toxic chemicals and pollutants. The optimum range of few most important water quality parameters for freshwater prawn culture are salinity (freshwater/ <5 ppt), temperature (28-32 ^{0}C), pH (7.0-8.5), total hardness (50-100 mg/I), dissolved oxygen (> 5ppm).

Quality of Seed

Selecting the best quality seed for stocking is one of the most important tasks in scampi culture. The PL brought to the farm need to be acclimatized to the pond water. In any case, the PL should be acclimatized to the temperature as well as pH of the pond water. Many farmers consider only the former by simply floating the seed bags in the pond before releasing the seeds. The, water in the seed bag and the pond water should be gradually mixed to avoid pH shock to the PL.

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Nursery Rearing

The PL are stocked, in small nursery ponds at high densities and reared for 1.0 to 1.5 months. The common practice is to stock nursery ponds at 2.0-2.5 lakh PL/ha. The PL should be fed a pellet diet or other suitable diet for at least 3 to 4 times a day (Gupta et al 2007). Zooplankton are an important food source for prawns, especially during the first few weeks after stocking. The nursery reared PL grow to juveniles and weigh about 3-5 g depending on the stocking density employed and management practice. These juveniles are used for stocking in grow-out ponds.

Pond Management

The important management practices needed includes pond preparation, feeding, water quality measurement, prawn sampling and finally harvesting.

i) Pond preparation: The steps involved in pond preparation includes, eradication of predators and competitors, application of lime and application of fertilizers (organic and inorganic). Bleaching powder and urea @ 300 and 100 kg/ha respectively can be applied to kill all predatory species in the pond. For this first urea and after six hours bleaching powder has to be applied. Stocking of prawn seed can be done two weeks after eradication of pests and predators.

Lime is applied @200-600 kg/ha depending on the soil pH. The lime used should be agricultural lime ($CaCO_3$) or dolomite ($CaMg\ CO_3$). The lime should be spread over the whole pond bottom and up to the top of the dyke. Lime helps to correct the pH and disinfects the pond bottom (Gupta et al. 2007). Lime is also a source of calcium, which is very important for exoskeleton formation of prawns. Cow dung @ 500 kg/ha and urea @ 10-30 kg/ha and super phosphate @ 20-60 kg/ha may be applied to initiate a plankton bloom. After the initial fertilization water can be filled up to the desired level (4-5 feet).

Provision of Hide Out

It is desirable to provide hideouts and more surfaces for clinging. Cut branches of trees, nylon screen, earthen/ plastic pipes etc. can be used as hideouts.

Stocking

Prior to stocking the pond water quality should be tested and necessary correction should be made. Care should be taken to acclimatise the post larvae to the temperature of the pond by floating the transport bags in the ponds for 20 min. Early morning and late evening are considered ideal period for stocking the seed. For semi-intensive culture a stocking rate of 5-7/m^2 is desirable. In poly-culture stocking density of prawn is reduced to 50% i.e. @ 25000/ha and compatible carp species such catla, rohu, silver carp and grass carp are also stocked @7000/ha (Table 1).

Table 1: Different fish species combinations for poly-culture of freshwater prawn

Fish species	Three species Combination (per ha)	Four species Combination (per ha)	Six species Combination (per ha)
Catla	2000	2000	1000
Silver carp			1500
Rohu	3000	3000	2000
Grass carp			1000
Mrigal	2000	1000	750
Common carp		1000	750
Total	7000	7000	7000

Food and Feeding

Pellet diets containing 35% crude protein are preferred for feeding freshwater prawn (Gupta et al 2011). Feed should be spread evenly along the peripheral area of pond. Feeding should be done during late evening and early morning as per the daily feed requirement (Table 2). Monthly sampling should be done to know the average body weight of prawn to adjust the feed quantity.

Table 2: Daily feed requirement of freshwater prawn

Prawn wt. (g)	%age of body wt. feed daily
<1	<20
2-5	15
5-10	10
10-30	5
>30	2

Water Quality Management

Daily monitoring of critical water quality parameters such as dissolved oxygen, pH, and temperature is essential to prevent any loss of stock due to poor water quality. Dissolved oxygen should be monitored during early morning. On cloudy days and rainy days depletion of oxygen may occur during daytime also. Phytoplankton bloom and

decaying waste material are the main reasons for dissolved oxygen depletion usually seen in prawn ponds. When the oxygen level in pond water is critically low then prawns come to the surface along the periphery of the pond. Immediate remedial actions such as water exchange or operation of pond aerators should be taken to avoid mortality of stock. Application of probiotics may be undertaken for water quality maintenance (Gupta et al. 2016).

Stock Monitoring

Growth of the animal is assessed by regular monthly sampling with cast nets or small mesh seine nets. The growth rate and survival of a population of prawn depends on many factors including density, predation, feed and temperature.

Health Management

Health management measures are given below:

» Maintaining a good rearing practice, avoid high density stocking and over feeding

» Provide hideouts to increase the total surface area of the pond and to reduce cannibalism

» Pelleted feed with 35% protein content is must for better production

» Regularly check feeding tray to ensure consumption of the feed

» Drying out the ponds between production cycles so that the beds can be re-oxidized

» Exchange water regularly which induces moulting

» Water quality should be tested to determine the DO; pH and ammonia levels and necessary corrections should be made

» Periodic harvesting is always preferred to reduce the heterogeneous growth pattern

» Protozoan parasites, bacteria and fungi cause diseases. Loss of appendages, brown or black coloration of the exoskeleton, etc. can be seen in disease affected prawns. They may not accept feed.

» If disease symptoms are noted water should be replaced

Harvesting, Processing, Marketing and Economics

Growth of the animal is assessed by regular monthly sampling with cast nets or small mesh seine nets. The growth rate and survival of a population of prawn depends on many factors including density, predation, feed and temperature. Because of the heterogeneous growth pattern of freshwater prawn, individual weight is highly variable for prawns of the same age. Periodic harvesting is always preferred.

After four months bigger size prawns (>30g) can be removed by using a seine net of suitable mesh size. Selective harvesting should continue once every 3-4 weeks for another 3-4 months and finally the pond may be harvested by complete draining. An average survival of 60% can be expected from a properly prepared pond, stocked with quality seed, fed with quality feed and monitored regularly to maintain optimum water quality. The average

a) *Economics of Monoculture of giant freshwater prawn*

S. No	Item	Amount (in Rs.)
I.	**Expenditure**	
A.	Variable Cost	
1.	Pond lease value (area: 1 ha)	10,000
2.	Prawn seed @ 60,000/ha @Rs. 1000/1000 Nos. with transportation cost	60,000
3.	Fertilizers and lime	6,000
4.	Supplementary feed (pellet form @ 3 t/crop @ Rs. 30/kg)	90,000
5.	Wages (One @ Rs. 3000/month for 9 months)	27,000
6.	Electricity and fuel	3,000
7.	Harvesting charges	5,000
8.	Miscellaneous expenditure	3,000
	Sub-Total	2,04,000
B.	**Total Cost**	
1.	Variable cost	2,04,000
2.	Interest on variable cost (@ 15% per annum for 6 months)	15,300
	Grand Total	2,19,300
II.	**Gross Income**	
	Sale of big size prawn (@ Rs. 450/kg for 700 kg)	3,15,000
	Sale of small size prawn (@ Rs. 350/kg for 300 kg)	1,05,000
	Grand Total	4,20,000
III.	**Net Income (Gross income – Total cost) (420000 - 219300)**	**2,00,700**

b) *Economics of Polyculture of giant freshwater prawn with carps*

S. No.	Item	Amount (in Rs.)
I.	**Expenditure**	
A.	Variable Cost	
1.	Pond lease value (area: 1 ha)	10,000
2.	Fish seed [7000 no./ha (@Rs. 300/1000 nos.)] = Rs. 2100/- Prawn seed [25,000/ha (@Rs. 1000/1000 nos.)] = Rs. 25000/-	27,100
3.	Fertilizers and lime	6,000
4.	Supplementary feed (pellet form @ 3 t/crop @ Rs. 25/kg)	75,000
5.	Wages (One @ Rs. 3000/month for 10 months)	30,000
6.	Electricity and fuel	3,500
7.	Harvesting charges	5,000
8.	Miscellaneous expenditure	3,000
	Sub-Total	1,59,600
B.	**Total Cost**	
1.	Variable cost	1,59,600
2.	Interest on variable cost (@ 15% per annum for 10 months)	19,950
	Grand Total	1,79,550
II.	**Gross Income**	
	Sale of prawn (@ Rs. 350/kg for 500 kg)	1,75,000
	Sale of fish (@ Rs. 60/kg for 2500 kg)	1,50,000
	Grand Total	3,25,000
III.	**Net Income (Gross income – Total cost) (325000 - 179550)**	**1,45,450**

expected body weight of prawns after 6-7 months of culture is about 40-60 g. Yield may range from 1-1.5 tonnes/ha/6-7 months. Scampi has got excellent international market.

It is exported mainly to Europe as a luxury item served in elite restaurants. The tail weight percentage is less (about 50%) than that for marine shrimp. This is also lesser for males than that for females, and also decreases with prawn size. Also there is a high rate (5%) of hanging meat. Dipping prawns in iced water ('kill chilling') prior to blanching at 65°C for 15-20 seconds, before icing and transport to market significantly improves quality. Beheading and intensive washing decreases initial microbial load and improves post storage quality.

The market rate for 1 kg of freshwater prawn is about Rs. 500-700, depending on number per kilogram. Lesser the number greater will be the cost.

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Sea buckthorn: A novel feed opportunity for livestock and poultry health, production & welfare

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Therapeutic

Abstract

Sea buckthorn commonly known as *"Cold Desert Gold"* due to its high potential as a bio-resource for land reclamation, reducing soil erosion, medicinal and nutritional properties in the leaves & fruits. In India, it's fruit is also known as Leh berries or miracle fruits. In ancient Greece, the leaves of Sea buckthorn when added to horse fodder were found to result in weight gain and shiny hair, thus the Latin name 'Hippo' means Horse and 'Phaos' means Gloss or flare i.e. 'Hippophae' meaning shining horse is an ancient plant with modern virtues, due to its nutritional and medicinal value. All parts of Sea buckthorn e.g. berries, leaves, and seed or pulp oils contain many bioactive compounds. They are a rich source of natural antioxidants such as ascorbic acid, tocopherols, carotenoids, fla-vonoids, while they contain proteins, vitamins (especially vitamin C), minerals, lipids (mainly unsaturated fatty acids), sugars, organic acids and phytosterols. livestock and human studies suggest that sea buckthorn may have various beneficial effects: cardioprotective, anti-atherogenic, antioxidant, anti-cancer, immunomodulatory, anti-bacterial, antiviral, wound healing and anti-inflammatory. Several studies showed that the leaves & fruit residues of SBT could be used to feed poultry and livestock without accumulation of toxins and the feed also had a stimulating effect on growth and performance of poultry birds & livestock. Therefore, it would be worthwhile to perform more scientific research on this medicinal plant and to promote its large-scale utilization for livestock and poultry health, production & welfare.

Introduction

Now a days there has been a growing interest by consumers, researchers, and the food industry about the ways in which some foods can help maintain human and animal health beyond their traditional nutritive value. The market for functional foods is increasing annually at a rate of 15% to 20%. The WHO considered that 80% of earth's population trust on traditional medicines for their prime health care, needs and utmost of this therapy involves the use of numerous plant extracts or their active constituents. Herbal supplementation can be serve as safer alternative as growth promoter, lower cost of production, reduced mortality, reduced risk of disease, minimum health hazards and environment friendliness. A number of medicinal plants have been investigated throughout the world for their efficacy in wound healing. Sea buckthorn is one such medicinal plants which has been proved to be a good wound dressing material in man and animals.

Sea buckthorn (*Hippophae rhamnoides*) is a thorny, dioecious, wind pollinated, multipurpose temperate bush plant bearing yellow or orange berries with nitrogen fixing abilities. It is commonly known as "cold desert gold" due to its various beneficial effects over plant, animal, human & soil health. Sea buckthorn is an important medicinal resource and is

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found in abundance in Indian subcontinent especially the North Western Himalayan regions (Dhanze *et al*., 2013). The plant inhabits dry temperate region and high altitude regions of Himachal Pradesh, Jammu & Kashmir and Uttrakhand. The native of this plant is European and Asian countries. In India, it is widely distributed at high altitude, cold arid condition of Ladakh and Lahul-Spiti, parts of chamba and upper Kinnaur districts of Himanchal Pradesh, Sikkim and Arunanchal Pradesh.

In ancient Greece, the leaves of Sea buckthorn when added to horse fodder were found to result in weight gain and shiny hair, thus the Latin name 'Hippophae' meaning shining horse, was ascribed to it (Rongsen, 1991a). Sea buckthorn (*Hippophae rhamnoides*) is a small shrub comprising of fruit and leaves that are rich in nutrients and bioactive components such as vitamins (Kudritskaya *et al*., 1989), amino acids (Repyakh *et al*., 1990), lipids (Goncharova and Glushenkova, 1993), sugars and acids (Yang, 2009), and flavonoids (Häkkinen *et al*., 1999). Sea buckthorn has antioxidant (Geetha *et al*., 2002a; Geetha *et al*., 2002b; Chawla *et al*., 2007; Püssa *et al*., 2007; Geetha *et al*., 2009), anti infective (Larmo *et al*., 2008) function and exerts beneficial effects on liver fibrosis (Gao *et al*., 2003) and immune function (Dorhoi *et al*., 2006). The crude protein, lysine, methionine + cysteine, calcium, and phosphorous content of Sea buck thorn leaves and seeds are 20.7% and 26.4, 0.73% and 0.42, 0.13% and 0.59%, 1.18% and 0.31%, 0.18% and 0.34% respectively. However, the crude protein, methionine + cysteine, calcium and phosphorous content of Sea buckthorn fruit residues have been found to be lower than leaves and seeds (18.3%, 0.06%, 0.19%, 0.15%) where as the lysine content of Sea buckthorn fruit residues has been found to be higher (0.84%) than leaves or seeds (Lu *et al*., 1991). Since, the leaves, seeds and fruit residues contain high crude protein, amino acid, calcium and phosphorus, they have advantages as basic materials for feed formulations for poultry. It has been observed that body weights of poultry have increased greatly after feeding leaves, seeds and fruit residues of sea buckthorn (Wang, 1997). Sea buckthorn has a large content of vitamin C, several folds as compared to other fruits (Christaki, 2012). The levels and balance of amino acid in diets are all important nutritional variables that affect the economic efficiency of an egg laying enterprise.

Berries and Seed of Sea Buckthorn

Berries as well as other parts of sea buckthorn represent a rich source of biologically active compounds. For this reason the plant has been in the centre of attention virtually world-wide. The chemical and nutritional composition of sea buckhorn berries as well as the content of bioactive compounds depend on many factors. The most important factors include different subspecies, origin, climate conditions, time of harvesting, and methods of processing (Bal *et al.,* 2011). Sea buckthorn and especially its berries provide a rich source of many minerals, including, but not limited to Ca, P, Fe, and K. Sea buckthorn has a large content of vitamin C, several-fold compared to other fruits (Christaki, 2012). The vitamin C content in sea buckthorn ranges between 360 and 2500 mg/100 g (Bal *et al.,* 2011). The plant is a valuable source of the vitamin B group, mainly B1 (thiamine) and B2 (riboflavin). Other vitamins rich in sea buckthorn include, for example, vitamin E (Michel *et al.,* 2012), vitamins A and K (Bekker and Glushenkova 2001; Fatima *et al*., 2012). The berries provide a good source of carotenoids, mainly ß-caroten, lycopene, lutein, and zeaxantin (Michel *et al*., 2012). The saccharide content is also high. The most common carbohydrates are glucose, fructose, and xylose. All parts of the plant contain many different proteins, mainly albumins and globulins (Li and Beveridge 2003). Sea buckthorn is a source of organic acids, mainly malic acid, quinic acid, oxalic acid, citric acid, and tartaric acid. Sea buckthorn is a good source of flavonoids too, mainly quercetin, kaempferol, myricetin, and isorhamnetin, and an important source of tocopherols (Fatima *et al*.,2012).

Table 1: Major Component of Sea buckthorn and their principal therapeutic effects (Michel *et al.,* 2012)

S. N.	Component	Therapeutic effect
1.	Tocopherols	Antioxidant activity, Minimization of lipid oxidation
2.	Carotenoids	Antioxidant activity, Contribution in collagen & epithelium synthesis
3.	Vitamin K	Haemorrhage prevention, Positive effects against ulceration
4.	Vitamin C	Antioxidant activity, Maintenance of cell intigrity
5.	Vitamin B complex	Nerve tissue regeneration, Cellular renewal stimulation
6.	Phytosterols	Anticarcinogenic effect, Antiatherogenic effect, Prevention of ulceration Regulate inflammatory processes
7.	Polyphenolic compounds	Antioxidant activity, Cyto-protective effect, Cardio-protective effect
8.	Poly unsaturated Fatty acid (PUFA)	Immunomodulating effect, Neuroprotective agents Anti-carcinogenic effect
9.	Organic acids	Wound healing support, Anti-carcinogenic effect Reduction of risk of arthritis
10.	Zinc	Blood circulation increase, Increased utilization of vitamin A Enzyme cofactor function

Sea buckthorn is a good source of mainly unsaturated fatty acids (Christaki 2012). The pulp oil contains 180–240 mg of carotenoids in 100 g, of them 40–100 mg in form of carotene, 110–330 mg of vitamin E and unsaturated fatty acids, mainly linoleic and linolenic acids. Specific types of acids include ursolic acid and oleanolic acid, with anti-inflammatory, wound healing, toning and blood pressure reducing effects (Valíèek and Havelka 2008). The pulp oil contains the highest concentration of palmitoleic acid (16:1, n-7), up to 43% (Fatima *et al.,* 2012). Sea buckthorn seeds contain 8–20% oil (Kumar *et al.,* 2011). The oil content is mainly affected by the harvest time, size, and colour of berries (Yang and Kallio 2002). Seed oil mainly includes unsaturated fatty acids – 90% (linoleic 47 mg, linolenic 18 mg, oleic 16 mg) and saturated palmitic acid (Valíèek and Havelka 2008). Seed oil is the only oil with the linoleic acid to linolenic acid ratio of 1:1 (Yang and Kallio 2002; Kumar *et al.,* 2011). Sea buckthorn is also a good source of oleic acid (Christaki 2012).

Sea Buckthorn Leaves

The leaves contain a remarkable quantity of proteins (20.7%) amino acids (0.73% Lysine, 0.13% methionine and Cystine), and other bioactive substances. They contain on average 3.8% of saccharides, 0.2% of protopectin, 1% of organic acids, 170 mg/100 g of catechin, polyphenols, carotenoid lycopene, bioflavonoids, and coumarins. The leaves also contain a significant concentration of vitamin C (up to 370 mg/100 g) and about 8% tannins (Valíèek and Havelka, 2008).

Beneficial Effect of Sea buckthorn on Livestock & Poultry

Several studies showed that the leaves & fruit residues of SBT could be used to feed poultry and livestock without accumulation of toxins and the feed also had a stimulating effect on growth and performance of poultry birds & livestock (Biswas *et al.,* 2010).

SB oil has a potent hepato-protective activity, reducing the concentration of aflatoxins in liver and diminishing their adverse effects in chicken broiler (Solcan *et al.*, 2013). There is various beneficial effect of SBT on livestock & poultry birds are as -

Anti-Visceral Obesity & Anti-Oxidant Effect

The potential health benefits of SBT leaf tea (SLT) in high-fat diet-induced obese mice for six week duration and it was observed that SLT suppressed body weight gain in a dose-dependent manner and significantly reduced visceral fat, plasma levels of leptin, triglyceride and total cholesterol and ALT activity compared with the high-fat-fed control mice. SLT also decreased hepatic triglyceride and cholesterol concentrations and lipid accumulation, whereas elevated fecal lipid excretion. These results indicate that SLT has potential anti-visceral obesity and antioxidant effects mediated by the regulation of lipid and antioxidant metabolism in high-fat diet-induced obese mice (Lee *et al.,* 2011).

Oxidative Stress & UV Radiation

Oxidative stress & oxidative photo-damage induced by UV radiation can cause serious skin damage characterized by wrinkling, roughness, laxity & pigmentation (Hwang *et al.,* 2012). Intrinsic aging is characterized by fine wrinkling & reduced elasticity whereas extrinsically aged skin exposed to UV light is associated with induction of both deep wrinkles & a significant loss of elasticity.

Wound Healing

Wound healing is a fundamental process in nature to store normal functions of body. Wound healing may be hastened by providing ideal environment which result in optimum response to healing. Wound healing properties of SBT oil are well established. (Vlasov, 2001; Gupta *et al.*,2001). Wound healing property of SBT is due to early formation of collagen which is exerted by rich content of vitamin A, C & E and micro-elements S, Se, Zn, Cu etc along with triterpene components which have regenerative & epitheliotropic properties (Xu, 1993).

Hepatoprotective Effect

Sea buckthorn extracts are effective as Neutraceuticals or food suppliments against liver diseases or CCl_4 induced liver injury in male albino rats (Geetha *et al.*, 2008) while Feeding of SBT berries @400 ppm & 800 ppm significantly improved the growth performance, immune response, histopathological, haematological, haematobio-chemical parameters & liver peroxidation (Ramasamy, 2010).

Anti-cold, Hypoxia & Restraint Stress

SBT extracts causes shift from anaerobic to aerobic metabolism during exposure of cold, hypoxia, restraint stress and post stress recovery in rat may be due to its anti-oxidant activity, sustained body glucose levels, better utilization of free fatty acids & improved cell membrane permeability. Polyphenols/

Flavonoids present in SBT helpful in protection of mitochondrial & genomic DNA from radiation induced damage. Alcoholic extracts of fruit & leaves of SBT have cryoprotective action against sodium nitroprusside induced oxidative stress (Geeta *et al*., 2002).

Immunomodulatory Effect

Compound extracts of SBT has a prophylactic effect through stimulation of macrophage function and enhancement of serum lysosome activity in in Mice & Guinea Pig (Zhong *et al.,* 1989). SBT extracts have positive effect to enhancing cellular & humoral immunity to animals (Li, 1993). SBT seed oils also helpful in restoring NK cells activity which is responsible for non-specific immune defense mechanism. SBT berries having immunoprotective effect against T2-toxin induced immuno dippression in broiler chickens (Ramsamay *et al.,* 2010). Essential oils extracted from SBT fruits improves the immune response of broilers (Lavania *et al.,* 2009)

Growth Performance

Supplementation of 0.5% & 1% SBT leaves was beneficial to improve growth performance & deposition of calcium and phosphorus. Feeding of SBT leaves in pigs increases the body weight by 9.4-21.3% and in goat raised their milk output by 6.2-6.8% while in poultry egg laying increased by 8.7-13.3%

Egg Production

SBT have potential effect for increase in egg production rate & body weight gain in laying hens (Wang, 1997). Twenty percent replacement of SBT cake in poultry layer bird significantly increased the fortnightly egg production (Hasanuzzaman, 2015) .

Conclusion

- Sea buckthorn is a good feed opportunity to improve food security as well as to improve livestock health, production & welfare.
- Sea buckthorn is a store house of many bio-active substances.
- Sea buckthorn oil can be used as mild anti-microbial & anti-inflammatory agent in wound healing.
- Having diverse pharmacological activities.
- Dietary supplementation of SBT increases the cell mediated immune response of broilers.
- Have a Great Nutritional value.
- Useful for Prevention of diseases, Egg production and Welfare of livestock & poultry birds.

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Global warming: Its effect on livestock and mitigation strategies

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Abstract

Climate change and livestock rearing are interrelated processes, both of which take place on a global scale. Livestock play an important role in economy of the developing countries like India. FAO estimates that per capita livestock production and productivity have been stagnant over the last two decades. This has been attributed to a number of production and productivity constraints including global climatic change. Climate affects livestock both directly and indirectly. Direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool production and reproduction.Indirect effects include climatic influences on the quantity and quality of feedstuffs such as pasture, forage, grain and the severity and distribution of livestock diseases and parasites. Understanding the impact of climate change on livestock productivity is crucial to mitigate theadverse impact on the gains from other efforts.

Introduction

The global livestock sector is growing faster than any other agricultural sub-sector. It provides livelihoods to about 1.3 billion people and contributes about 40 percent to global agricultural output. For many poor farmers in developing countries livestock are also a source of renewable energy for draft and an essential source of organic fertilizer for their crops.

With increased prosperity, people are consuming more meat and dairy products every year. Global meat production is projected to more than double from 229 million tonnes in 1999/2001 to 465 million tonnes in 2050, while milk output is set to climb from 580 to 1043 million tonnes. But such rapid growth exacts a steep environmental price, according to the FAO report, *Livestock's Long Shadow –Environmental Issues and Options*. "The environmental costs per unit of livestock production must be cut by one half, just to avoid the level of damage worsening beyond its present level," it warns.

When emissions from land use and land use change are included, the livestock sector accounts for 9 percent of CO_2 deriving from human-related activities, but produces a much larger share of even more harmful greenhouse gases. It generates 65 percent of human-related nitrous oxide, which has 296 times the Global Warming Potential (GWP) of CO2. Most of this comes from manure. And it accounts for respectively 37 percent of all human-induced methane (23 times as warming as CO2), which is largely produced by the digestive system of ruminants, and 64 percent of ammonia, which contributes significantly to acid rain.

Climate change and agriculture are interrelated processes, both of which take place on a global scale. One of the biggest issues facing us right now is global warming. Its effects on animals and on agriculture are indeed frightening, and the effects on the human population are even scarier. The facts about global warming are often debated, but unfortunately, even if we disagree about the causes, global warming effects are real, global, and measurable. The causes are

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mainly from us; the human race, and the effects on us will be severe.

Global warming and climatic change is caused by increased level of carbon dioxide and other gases (Called greenhouse gases) in our atmosphere. These gases trap heat by forming a blanket around the earth. Once released, the greenhouse gases stay in the atmosphere for several years. Table 1 indicates the relative amount of green house gases. As they build up, the earth temperature rises and aversely affects the agriculture process including livestock. Estimates of Institute for International Economics & the Center for Global Development (Washington, USA) states that Global warming will cause 16% decline in global agricultural GDP by 2020.Projects output to fall by 20% in developing countries and by 6% in industrialized nations.

CO_2	40%	Sources: Fossil fuel, oil, gasoline
CH_4	18%	industry, livestock & paddy field
N_2O	6%	
CFC, CO, CCI_4	14%	Refrigeration

General Effects of Global Warming

1. Higher local temperatures.
2. Extreme weather (floods, longer droughts)
3. Changes in rainfall pattern
4. Some regions will have increased rainfall while others will have decreased water availability.
5. Increased evaporation.
6. Glazier retreat and disappearance
7. Rise in sea level
8. Acidification.

Effects of Global warming on Livestock Health

1. Erratic Climatic changes: Global warming leads to high environmental temperature, extreme solar radiation, sudden changes in climatic factors like heat waves in winter, heavy rain fall in summer and cold waves in monsoon in tropical regions. Though livestock are homeotherm, they cannot able to adjust themselves in sudden climatic changes leading to lower productivity, health problems and mortality.
2. Decrease in feed intake: A decrease in feed and energy intake results in decreased blood flow to the tissues of the digestive system in heat stress affecting adversely the digestibility of feed lowering the productivity. Heat stress during the late pregnancy, in particular limits the development of fetus and placental mass indirectly affecting the subsequent lactation. Besides, high temperature with high humidity is more deleterious for female fertility leading to more numbers of non-ovulatory cycles because of lower estradiol concentration especially in buffaloes. The embryonic signal in heat-stressed cows is so weak that it may not sufficient to block PGF_2á production by uterine endometrium, which in turn causes luteolysis and termination of pregnancy. Heat also reduces the metabolism and results in retarded fetal growth.
3. Respiratory problems: Higher ozone concentrations at ground level damage lung tissue.
4. Increase in cardiovascular disease.
5. Decreased resistance to diseases due to increased climatic stress.
6. Increase in favorable zones for vectors and thereby increasing vector born diseases like blue tongue and nipah viruses.
7. Drought leading to unavailability of safe drinking water.
8. Floods resulting in death of grazing livestock.
9. Higher mortalities.
10. Translocation of livestock due to global warming can affect wildlife with vector-borne diseases.

Effects of Global warming on Livestock Production

1. Decrease in productivity due to effects of higher temperature and greater temperature extremes on animal physiology and performance.
2. Change in husbandry practices-production system; water, feed and other resource used.
3. Fall in agricultural productivity resulting decrease in grain feed supply which increases animal feed price and cost of animal production.
4. Global warming causes plant nutrient deficiencies producing poor quality feed and thus affecting animal productivity.
5. Habitat affected leading to poor adaptability.
6. Reduced ruminal contractions, higher rectal temperature and reduced milk yield

Mitigation of Global Warming Effects on Animal Production

1. Use of Closed-House systems for livestock production to protect the environment from livestock habitats.
2. *Altering the Cow's Environment:* providing the

shed to protect the cow from direct and indirect solar radiation. Animals should be kept under trees in loose housing system in heat stress condition to prevent adverse changes in body parameters and milk production if closed house system is not available.

3. Reformulation of nutrient requirements for cattle to account for reduced DMI, dietary heat increment, and avoiding nutrient excesses during hot weather. 3 to 5% fat should be incorporated in ration, as heat increment of fat is less than protein and carbohydrate. Dietary protein density should be increased (21% CP) to compensate for lower feed intake and to maintain the milk production. In addition dietary mineral concentration should be increased. Milk production and feed intake improves with addition of 0 .85% sodium bicarbonate in heat stressed lactating dairy cows. Besides monensin is given @30mg/day alone or in combination with UMMB could reduce the methane production upto the extent of 32%, respectively. Methane production can also be aimed to reduce by feeding molasses urea product at a level of 600g with simultaneous increase of milk yield @1.3kg in buffaloes and 1.0 kg in crossbred cattle. Similarly, methane production can also be reduced by feeding of feeds containing bypass nutrients (protein & fat). Chaffing of fodder (dry and green) and frequency of feeding if increased reduce methane production.
4. Development of high yielding animals through proper breeding program.
5. Development of heat-resistant animals through breed improvement.
6. Water stress: Use of animal species, which consumes less water vis-a-vis their body, mass: e.g. sheep and goats have better water consumption patterns than cattle.
7. Reduce environmental pollution: zero-discharge from livestock farms.
8. Reduce emission of methane, nitrous oxide and Co_2: Technology use e.g. adding cysteine into fed, harvesting biogas from livestock manure (biogas reactors). Farmers keeping more than 10 animals and Panjrapole should be forced to use biogas technique to utilize methane production as fuels and reduce emission from animal waste. Enhancement of community biogas project should be made more attractive by the Govt. Govt. and NGOs should campaign to create awareness among the farmers that community manure storage at the bay of village should be by pit method instead of heap method (presently 93% heaps)
9. Development of technology that can be applied to mitigate the effect of global warming.
10. Use of land resources optimally. Controlling access and removing obstacles to mobility on common pastures. Use of soil conservation methods and silvopastoralism, together with controlled livestock exclusion from sensitive areas; payment schemes for environmental services in livestock-based land use to help reduce and reverse land degradation. Herds cause wide-scale land degradation with about 20% of pasture considered as degraded through overgrazing, compaction and erosion. This is due to inappropriate policies and inadequate livestock management, which contribute to advancing desertification.
11. Atmosphere and climate – increasing the efficiency of livestock production and feed crop agriculture. Improving animals' diets to reduce enteric fermentation and consequent methane emissions, and setting up biogas plant initiatives to recycle manure.
12. Water – improving the efficiency of irrigation systems. Introducing full-cost pricing for water together with taxes to discourage large-scale livestock concentration close to cities.
13. Give tax incentives to farms, which undertake carbon sequestration.
14. Develop effective legislative framework to impose ban on growing forage crops near highways as it leads to accumulation of heavy metals and hydrocyanic compounds into the fodders. Contaminated untreated wastewater for raising fodder crops should also be banned as it leads to emission of gases along with fodders.

Conclusion

The postulated effects of global warming on animal health and production are not fully known. More in depth and integrated studies are needed to fully elucidate the ramifications of global warming on livestock productivity, socio-economic effects and impacts on the nation and region as a whole.

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Aquaculture practices: Significance and strategies for increasing fish production

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Abstract

Fisheries and Aquaculture are playing an important role in addressing nutritional and livelihood security, especially of the rural poor in developing countries. Fish are rich sources of protein, essential fatty acids, vitamins and minerals. The fats and fatty acids in fish, particularly Omega 3 fatty acids, are highly beneficial and difficult to obtain from other food sources. The growing gap between supply and demand globally will impact on the health and nutrition of low income families, unless efforts are made to increase the production to meet the growing demand.

Aquaculture is the culture of Aquatic organisms under controlled conditions. Present concept of aquaculture incorporate culture of all aquatic organisms by following certain management techniques which includes water quality,choice food etc. and to protect them from unwanted predators, diseases, pollutants or any other things which are harmful to them. The aquatic organisms which are normally used for aquaculture for food purpose include fishes, prawns, shrimps, crabs, mussels and some live food organisms like algae and zooplankton.

Introduction

Aquaculture is essentially an Asian farming practice. India is endowed with vast and varied aquatic resources, of which only about 30% is utilized today for aquaculture. Aquaculture is a new name for what once we called 'fish culture'. Aquaculture continues to increase in volume and value of output in many countries of the world, filling the gap between the supply and demand for fish and fishery products, improving nutrition and contributing to the household economy, particularly in rural areas. There is immense scope for the betterment of mankind through aquaculture. Currently, China leads in Aquaculture production in the world followed by India, but the difference in production is almost 8-9 times. In India the Aquaculture average growth rate is about 8%.

Importance of Aquaculture

- Aquaculture has been found to be a productive enterprise compared to traditional agriculture practices.
- In aquaculture practice, fish can be crowded more closely (200/m^2) and grown as in super intensive fish culture practices like water recirculation system due to their three dimensional utilization of the water column. Through such a practice, a fish yield of 25 tons/ha/yr has been recorded.
- As the FCR is known to be 1.5 times more in fish compared to chicken and two times more than in cattle and sheep, fish production in aquaculture by supplementary feed is higher than that of the livestock.
- Aquaculture especially 'Integrated fish farming' with agriculture and animal husbandry is known to be more profitable than agriculture alone.
- Aquaculture gives efficient means for recycling agricultural and domestic wastes, in order to help/ protect our environment
- Many high valued and commercially important items such as prawns, lobsters, frog legs, ornamental fish and many other aquatic organisms helps in

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earning good foreign exchange.

- Artificial recruitment in the water bodies by fish seed produced in fish hatcheries through aquaculture (ranching), could certainly add new fishery resources or increase existing fish stocks.
- Aquaculture could help in generating employment for many unemployed and under-employed people. Such a step would help to stop the migration from villages to urban areas.
- From the point of view of human nutrition, the fish food is not only easily digestive but is also rich in essential amino acids like lysine and methionine. The unique poly unsaturated fatty acids (PUFA) namely, eicosapentaenoic acid of fish is known to reduce the cholesterol level of blood and save human beings from coronary disease. Further, vitaminsand minerals are also present in good quantities in fish.

Types of Culture Systems

Aquaculture is conducted in all the three types of aquatic environments:

1. *Freshwater aquaculture:* It involves the culture in the water bodies having salinity level of less than 0.5 parts per thousand (ppt).
2. *Brackish water aquaculture:* It involves the culture in the water bodies having salinity level ranges from 0.5 to 30 ppt, and;
3. *Mariculture or sea farming:* It involves the culture in the water bodies having salinity level of more than 30ppt.

The species of flora and fauna inhabiting the three types of water bodies are accordingly called freshwater species, brackishwater species and marine species. Freshwater which is most extensively used sector of aquaculture, is further divided into two segments.

a) *Cold waters* of higher altitudes having temperature range of Â 18p C and
b) *Warm waters* of plains having temperature range of Ã 18p C

Aquaculture practices in these waters are, therefore, called coldwater aquaculture and warm water aquaculture, respectively. Aquaculture is practiced through various methods. Freshwater aquaculture is carried out in fish ponds, fish pens, fish cages, raceways and on a limited scale in paddy fields. Culture of fishes in ponds is the oldest form of aquaculture.

Different Levels of Aquaculture

Depending on the intensity of operation and degree of management, aquaculture practices are classified into following four operations/levels:-

1. Extensive aquaculture
2. Semi- intensive aquaculture
3. Intensive aquaculture
4. Super intensive aquaculture

Extensive Aquaculture

In extensive level of aquaculture, low stocking densities of 2000-5000 carp fingerlings are used and no supplemental feed is given. Fertilization may be due to stimulate the growth and production of natural food in the water. In such types of culture system, carp culture does not require water exchange during culture period. The ponds used for extensive aquaculture are usually large (more than 100 ha.). The production is generally low, less than 0.5 ton/ha/yr in the case of carps.

Semi-Intensive Level

Semi-intensive aquaculture uses medium size ponds 0.5 ha each with comparatively higher stocking densities than extensive aquaculture (5000-10000 carp fingerlings/ha). Supplementary feeding is done in moderate amounts. In carp culture, water replenishment is done once or twice a month @10%. The production averages around 3-7 tons/ha/yr of carps.

Intensive Level

In intensive level of aquaculture, the pond size is generally small (about 0.2 ha approximately) with very high density of culture organisms i.e. 20000 to 25000 carp fingerlings/ha are stocked. The system is totally dependent on the use of formulated feeds. Feeding of the stock is done at regular intervals. Water replacement under intensive culture is effected on a daily basis. Production under intensive level of aquaculture is much higher, for example, about 12 to 15 tons/ha/year in carp culture.

Super-Intensive Level

Super intensive aquaculture needs running water supply and complete daily water exchange is performed. This system is mostly practiced in cement tanks, fiberglass tanks and raceways etc. which are fitted with high efficiency biological filters for continues recirculation of water. The size of the tank ranges between 50-100m^3. The cultured organisms are fed with high quality formulated feed. The feed is given through demand feeders. The water quality is

regularly monitored with electronic gadgets. Stocking density ranges between 40,000 to 50,000 carp fingerlings/ha. The production ranges between 15-20 tons/ha/yr in case of carps.

Untapped Potential

- Only one third of freshwater aquaculture and 13% of brackish water resources have been utilized for aquaculture
- Average yield – 2.2 tons / ha / yr based on FFDA ponds
- Reservoirs fisheries is highly under-utilized (Av. annual yield – only 20 Kg / ha)
- Semi-intensive primary production based aquaculture of low – valued food fish has the potential to be adopted by millions of small holders
- At micro-level fish and livestock farming are key source of income and buffer against food insecurity

Objectives for Aquaculture Development

- Commercialization of aquaculture for maximization of production
- Food and nutritional security
- Export earnings
- Employment Generation
- Poverty reduction through livelihood development

Important Cultural Practices of Aquaculture

- Composite fish culture
- Integrated farming system
- Raceway culture
- Cage culture
- Pen culture

Composite Fish Culture

A fish pond is a complex ecosystem as the surface is occupied by the floating organisms such as phyto and zoo plankton; the column region has live and dead organic matter sunk from the surface and the bottom is enriched with detritus or dead organic matter. The marginal areas harbor a variety of aquatic vegetation. The different trophic levels of a pond could be utilized for increasing the profitability of fish culture. Keeping this in mind, the concept of Composite fish culture has been developed. The main objective of this culture system is to select and grow compatible species of fish of different feeding habits to exploit all the types of food available in the different nook and corners of the fish pond for maximizing fish production (New 1995, Gupta et al 2011, Gupta et al 2016).The common species of carps having compatibility and different feeding habits and which comes under composite fish culture are Indian major carps such as catla, rohu and mrigal and exotic carps such as common carp, silver carp and grass carp.

Integrated Farming System

Here, otherwise waste output of one enterprise can be utilized as inputs for other enterprise.

- Wastes/by products produced through agriculture are consumed by cattle and fishes and converted to proteins that build up animal flesh.
- Water from fish ponds can be used as inputs for agriculture/horticulture crops as well as for veterinary enterprises. Mud from fish ponds can be utilized as organic fertilizer for agriculture/ horticulture crops.
- All the wastes from veterinary enterprises are utilized as inputs for aquaculture and agriculture.

Cage Culture

Cage aquaculture is a method used for raising aquatic organisms (fish, prawns, molluscs, crabs etc.) within an enclosure, which is installed in suspended state in ponds, reservoirs, lakes, rivers or any other large size water body. In India, it is initiated with the raising of fry (20-25 mm) to advance fingerlings (100-150mm) in water bodies/reservoirs to increase their production. Cages can be of various shapes and sizes. Rectangular cages are however, preferred for easy operation and management.

Pen Culture

Aquaculture in pens implies rising of required aquatic organisms (fish, prawn, molluscs etc.) in an enclosure which is formed by cordoning off areas of an open water body such as inter-tidal areas of the sea or fore shore waters of lakes, reservoirs, river, wet lands etc by net barriers.

Pens are generally constructed on the shore side, in semi-circular, rectangular or square shapes as per the suitability of the site. They are constructed by barricading the other three sides by a wall of nylon netting hung from poles driven to the bottom. The framework is generally made out of bamboo and other

locally available wood.

Raceway Culture

Raceways are designed to provide a flow through system to enable the culture/rearing of much denser population of aquatic animals. An abundant flow of good quality, well oxygenated water is essential to provide respiratory needs and to flush out metabolic wastes, particularly ammonia. Raceways are obviously smaller in size than ponds and occupy much less space. Site selection for a raceway farm has to be done with special care. Naturally the most important consideration is the water supply. The main source of water is springs, streams, deep wells and/or lakes.

Future Needs/Strategies

- Stocking of yearlings / overwintered fingerlings
- Making best use of warmer period
- Periodical harvesting
- Stocking of species in demand and price
- Develop Complementarities among the various farming practices
- Production of low valued carps as well as high valued fish to fulfill the gap between demand and supply
- Strengthening of domestic markets
- Develop Aquaculture as the main source of rural livelihoods and income generation
- Production enhancement through Aquaculture
- Provision of training and education in Aquaculture
- Optimum utilization of resources for sustainable increasing production
- Identification of water bodies/stretches for conservation and replenishment of depleted stocks through ranching
- Restoration and regular stocking of fingerlings in floodplain wetlands and other natural water bodies
- Increase the rearing area by establishing more seed rearing units, pen and cage culture systems
- Strengthening of welfare schemes for the upliftment of community
- Human resource development in the sector

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