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Fish seed supply trends for adoption of aquaculture in Himalayan region of Uttarakhand

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ABSTRACT

A trend of fish seed supply of cultivable carps from Fish Hatchery, College of Fisheries, G.B. Pant University of Agriculture and Technology, Pantnagar to different parts of Uttarakhand state has been studied for a decade period from 2009 to 2019. The observation shows that total annual fish seed supply to the fish growers varied from 20.5 lakh to 55.01 lakh with number of beneficiaries ranging from 123 to 281. However, in Shivalik range of Uttarakhand (3000-4000 feet asl) where average water temperature varied from 10- 30 ^{0}C, seed supply varied from 41870 to 601050 seeds involving 16 to 44 fish growers per year. During the investigation period, the farmers from almost all hilly districts of Uttarakhand and from parts of Nepal have procured fish seed of commonly cultivable carps. Though the farmers from these hilly areas prefer seed of grass carp, amur common carp and silver carp but they also procure small quantity of seed of Indian major carps. Introduction of Amur common carp in College hatchery during 2011 and availability of seed regularly from 2013 in place of existing common carp is also helping in increasing fish production in hilly region of the Uttarakhand. Among all the hilly districts of Uttarakhand, Chamoli received maximum quantity of fish seed (77000) during 2009-10 while highest numbers of beneficiaries were from Nainital (14 farmers/ year) during 2010-11. Available data also indicated that highest quantity of fish seed was supplied during July while lowest in January. These observations are indicative of the fact that interest of farmers in hilly regions of Uttarakhand is increasing to adopt fish culture for enhancing their income.

1. Introduction

Agriculture is a significant contributor to Uttarakhand Gross State Domestic Product. It is the chief source of livelihood for over 70% of its population (Roy *et al.*, 2013). The State is included in the National Agro-Climatic Zone 9 and 14 (Tuteja, 2013). The economy of the state is primarily based on agriculture and allied activities including fisheries (Kandpal, 2013). Fisheries is the part of agriculture which play an important role in upgrading socio-economic conditions of the people dwelling in the hilly and plain regions of the state. It is considered to be one of the vital sectors for economic development of the state. Farmers in hills are dwelling in a complex, diverse and risk prone situation. They are usually practicing traditional ways of cultivation which adds very little in the system as input. There are several improved farm practices viz. improved cereals, pulses, millets, vegetables and fodder; water conservation, protected cultivation, vermin composting, honey bee rearing, mushroom cultivation, fish production etc. which can produce higher yield, and in turn give good return with proper utilization of natural resources, sustainable livelihood security and food & nutritional enrichment (Roy *et al.*, 2013).

Aquaculture with more than 9% compound growth rate is emerging as sunrise industry in the present decade (FAO, 2020). Bestowed with vast area of inland water resources in the form of fast flowing rivers and their tributaries (2700 km), reservoirs (20075 ha), high and low altitude natural lakes (297 ha) and ponds/ doggies (2844 ha), the state Uttarakhand has tremendous scope for fisheries development (Mishra and Sharma, 2020). The upland region of the state provides conducive ecology for culture and

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capture of coldwater fish where as plain areas are suitable for culture operations of Indian major carps and exotic carps. Apart from these aquatic resources the state is not producing adequate quantity of fish as per the demand of the state. During 2018-19, the state Uttarakhand produced 4320 tons fish and 65.56 million fish seed (DoF, 2020) which is much lesser than the actual demand (Sharma and Mishra, 2009). One of the main constraints in fish production is the availability of quality fish seed in required quantity. The supply of quality seed is a key factor to the expansion of fish farming. Seed is the primary input in any culture systems; its production has been accorded highest priority in terms of broodstock management, establishment of hatcheries and refinement of induced breeding techniques, rearing and production of quality seed (Gupta and Rath, 2011). The relationship between fish seed production and fish production is strong and closely related (Maurya *et al.*, 2018). Production of marketable fish begins with stocking of fry or juveniles into a rearing environment that assured optimum and rapid growth to allow harvest in shortest possible time period. Further due to decline in fish production from capture fishery resources, it becomes imperative that more focus is laid on the development of aquaculture sector.

Availability of quality fish seed to fish farmers is the most critical input for fish culture in the ponds and tanks to enhance fish production (Ghosh *et al.*, 2017). The role of seed sector is not only to ensure the timely supply of adequate quantity of quality seeds to farmers but also to achieve varietal diversity to suit various agro- climatic zones. Availability of variable and vigorous seeds of genetic purity at planting time is very important for achieving target of agriculture and aquaculture production because they act as a catalyst for realizing the potential of other inputs, such as manures, pesticides, herbicides, irrigation and crop management (Tuteja, 2013). The College of Fisheries, G.B. Pant University of Agriculture and Technology, Pantnagar has been producing quality fish seed of cultivable carps for more than four decade and making them available to the fish growers throughout the year. The availability of high quality seed of desired fish species in required quantities is one of the major factors that lead to success of fish production (Jha *et al.*, 2019). The availability of quality fish seed in the State encouraged the fish famers to expand the fish farming area and increase production (Statista, 2021). Fish seed production in Uttarakhand is limited to cultivable carps (Indigenous and exotic), trout (Rain bow and brown trout) and mahseer (Golden and Chocolate mahseer). A study of fish seed supply trend from College of Fisheries, Pantnagar to the fish farmers of Uttarakhand and nearby States has been made for a decade period from 2009 to 2019. During this period, the farmers from almost all hilly districts of Uttarakhand like Nainital, Almora, Bageswar, Champawat, Pithoragarh, Pauri, Tehri, Rudraprayag, Dehradun, Chamoli and from parts of Nepal have procured fish seed of commonly cultivable carps *viz.* Grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), Amur common carp (*Cyprinus carpio haematopterus*) and Indian major carps (*Labeo rohita*, *Labeo catla* and *Cirrhinus mrigala*) from the fish hatchery of College of Fisheries, Pantnagar. Fish culture from Nepal is limited mainly to seven species of indigenous and exotic carps (Jha *et al.*, 2019).

Considering the above facts, the fish seed supply trend from College of Fisheries, G.B. Pant University of Agriculture & Technology, Pantnagar especially to hilly region has been studied with the objective to know the present status of fish farming in the state and number of fish farmers who adopted this farming technique. The results of this investigation have been described further.

2. Materials and Methods

The fish seed supply trend in the Himalayan region from circular carp hatchery, College of Fisheries, G.B. Pant University of Agric. & Technology, Pantnagar has been studied for a decade period from 2009 to 2019. The circular carp hatchery of College of Fisheries is located in Tarai region of Uttarakhand at the coordinates $28^{0}58^{'}$ N latitude, $79^{0}30^{'}$ E longitude and 243.84 m ASL altitude which has humid sub tropical climate (Table 1) characterized by hot and dry summer and very cold winter (Tiwari, 2008; IMD, 2015). The hatchery is producing quality fish seed of cultivable carps viz. *Labeo rohita, Labeo catla, Cirrhinus mrigala, Ctenopharyngodon idella, Hypophthalmichthys molitrix* and *Cyprinus carpio haematopterus* during their breeding season following standard breeding procedure (Jhingran, 1991) and supply the advance fry and fingerlings (3.5- 6 cm size) stages to the desired farmers. The synthetic hormones Ovaprim (M/s Syndel Laboratories Ltd., Canada) and Gonopro FH (M/s APC Nutrients Pvt. Ltd., Secundarabad) were used for the induced breeding of indigenous major carps and exotic carps except Amur common carp. For the induced breeding, mature, healthy and disease free broodstock (male and female) were selected in the morning hours (7- 9 am) and injected with selected synthetic hormone @ 0.5 ml/ kg body weight to the female and 0.2 ml/ kg body weight to the male during evening hours (Sharma and Mishra, 2018). The hormones were injected intramuscularly just behind the dorsal fin. The yolk sac absorbed spawn of the fish were fed daily with crumbled feed (32% protein) following standard rate (Desilva and Anderson, 1995). The recommended quantity of fish seed was generally packed in 18 liter capacity polythene bags (18 x 28 inch and 250 gauge thickness) along with 1/3 part water and 2/3 part oxygen (Sharma and Mishra, 2018) during morning hours to reach them to the farmer's

Table 1. Climatic condition of Tarai region (Pantnagar)

S. No.	Climatic factors	Annual variation
1.	Average atmospheric temperature (^{0}C)	15.8- 30.5
2.	Minimum temperature (^{0}C)	1.9- 24.9
3.	Maximum temperature (^{0}C)	21.6- 38.9
4.	Relative humidity (%)	17-90
5.	Average annual rainfall (mm)	1000- 1200 (1433.4)
6.	Potential Evapotranspiration (mm)	1400- 1800
7.	Latitude (N)	28^{0}58'
8.	Longitude (E)	79^{0}30'
9.	Altitude (m ASL)	243.84

(Source: Tiwari, 2008)

pond within 12 hours time period. The collected data of fish seed supply from fish hatchery was analyzed for descriptive statistics using Microsoft excel.

3. Results and Discussion

Fishery resources of Uttarakhand comprise of fast flowing rivers and their tributaries, reservoirs, high and low altitude natural lakes, ponds and doggies (Tuteja, 2013). The Himalaya is having more than 33000 km^2 of glaciated basins that store approximately 12000 km^3 of freshwater. Supply of freshwater in the hilly districts of Uttarakhand are mostly dependent on rivulet and springs as 48.02% and 14.04%, respectively of total water supply which is the main water source for fish culture (Kumar *et al*, 2019). The water bodies of Uttarakhand are excellent source of fish production but fish production status (Table 2) of the State is not much satisfactory (DoF, 2020). Notwithstanding the good potential for fish culture in the Himalayan waters, the aquaculture of cold water fish has been a small-scale activity in mountain area (Mishra and Sharma, 2020). While about 40% of the total fish production in India comes from capture fisheries, it is much higher up to 95% in the Uttarakhand (Muruganandum *et al*., 2014; FAO, 2020). The upland region of the state provides conducive ecology for culture and capture of coldwater fishery as plain areas are suitable only for culture operations of Indian Major carps and exotic carps (Tuteja, 2013). Introduction of composite fish farming using Chinese carps for mid- altitude is a major success in increasing the fish production from the hilly region (Singh, 2016). The ponds located in the lower hills are used mainly for culture of carps. Integrated fish farming for the hills could also be an important inexpensive aquaculture practice for the rural population residing in the mountain areas of the country. About 80% of the ponds in the hilly region are irregular and polygonal in shape with average water depth of 0.7 m with a wide range of 0.45- 5.0 m during different seasons. Though, there is poor status of organized fish farming although it may provide good opportunities for socio- economic developments in foothills and mid hill Himalaya as one of the prominent farming avenues owing to the presence of abundant water resources and fish demands (Muruganndam *et al*., 2014). The fast growing exotic species, such as amur common carp, silver carp and grass carp are the major component of cultivable species in the hilly region (Jha *et al*., 2019). These fishes have been successfully cultured in the ponds in several hill districts of Uttarakhand (Sharma and Mishra, 2009; Sharma *et al*., 2018).

Table 2. Fish and fish seed production status in Uttarakhand

Year	Production at national level			Production in Uttarakhand	
	Total fish (000 tonnes)	Inland fish (000 tonnes)	Total fish seed (million fry)	Total fish (000 tonnes)	Total fish seed (million fry)
2009-10	7998.0	4894.0	29313.0	3.16	34.47
2010-11	8231.0	4981.0	34111.0	3.49	100.44
2011-12	8666.0	5294.0	36565.0	3.82	100.16
2012-13	9040.0	5719.0	34920.0	3.83	42.98
2013-14	9579.0	6136.0	41448.0	3.85	44.43
2014-15	10260.0	6691.0	39349.0	3.89	48.57
2015-16	10762.0	7162.0	35435.0	3.94	62.90
2016-17	11431.0	7806.0	35744.0	4.14	74.65
2017-18	12590.0	8902.0	44421.0	4.30	67.88
2018-19	13420.0	9710.0	48197.0	4.32	65.56

The seed is undoubtedly the basic and the most vital single input that play a key role in boosting agricultural and aquaculture productivity (Gupta and Rath, 2011). The role of seed sector is not only to ensure the timely supply of adequate quantity of quality seeds to farmers but also to achieve varietal diversity to suit various agro climatic zones (Tuteja, 2013). For sustainable and profitable fish farming quality fish seed of the candidate species in adequate quantity is one of the most important factors (Bisht *et al.*, 2013). The production of marketable fish begins with stocking of fingerlings into a culture pond that ensures optimum and rapid growth to allow harvest in the shortest time. Fish farmers have to stock adequate number of seeds for better production (Gupta and Rath, 2011). During 2018-19 the state Uttarakhand produced about 65.56 million fry (Table 2) which is approximately two times higher than the fish seeds produced during 2009-10 *i.e.* 34.47 million fry (DoF, 2020). There are about 3700 farmers from various parts of the state benefitting from State Integrated Cooperative Development Project 'UttaraFish' which integrate almost all facets of fish farming to form a unified system for farmers and cooperative societies (Upadhyay, 2021).

The fish hatchery of College of Fisheries, Pantnagar is involved in producing seeds of commonly cultivable carps viz. *Labeo rohita, Labeo catla, Cirrhinus mrigala, Ctenopharyngodon idella, Hypophthalmichthys molitrix etc.* and supply them to the desired farmers throughout the year. Quantity of annual fish seed supply and number of beneficiaries obtained fish seed during the decade 2009 to 2019, monthly fish seed supply, district wise fish seed supply in hilly region *etc.* are depicted in the tables 3 to 8 and figures 1 to 7. During the study period, the annual fish seed supply varies from 20.5 lakh to 55.01 lakh with number of beneficiaries ranging from 123 to 281 annually. However, in Shivalik range of Uttarakhand (3000-4000 feet asl) where average water temperature varied from 10- 30 ^{0}C, seed supply varies from 41870 to 601050 fingerlings involving 16 to 44 fish growers per year.

Generally, carp hatcheries begin the seed production activities during February and continued up to September every year (Jha *et al.*, 2019). The fish seed production activities also starts during February in Tarai region (Pantnagar) and goes up to September. Though the reported fish hatchery produce different stages of carp seed *viz.* post larvae, fry, advance fry, fingerling *etc.* but supply mainly fingerling stage as it is best stocking stage for sustainable fish production. The demand of seeds of cultivable carps generally starts from March and ends before onset of winter season. In the present study the total seed supply from Pantnagar fish hatchery varied from 20.5 lakh (2013-14) to 55.01 lakh (2018-19) with average supply of 34.33 ± 10.92 lakh per year while in hilly region it varied from 0.42 lakh (2013-14) to 6.01 lakh (2018- 19) with mean value of 1.61± 1.67 lakh seed per year. The share of fish seed supply in hilly areas varied from 2.05 to 10.92% with average value of 4.26 ± 2.68% (Table 3, figures 1 & 2).

Table 3. Annual variation in fish seed supply and beneficiary number

Year	Fish seed supply (In lakh)		% sharing in hills	Beneficiary number		% sharing in hills
	Total	In hills		Total	In hills	
2009-10	49.50	2.81	5.67	219	34	15.52
2010-11	25.00	1.44	5.76	247	44	17.81
2011-12	32.00	0.98	3.06	123	21	17.07
2012-13	25.00	0.68	2.72	164	16	9.76
2013-14	20.50	0.42	2.05	193	20	10.36
2014-15	24.50	1.07	4.37	198	28	14.14
2015-16	35.00	0.82	2.34	214	32	14.95
2016-17	37.51	1.03	2.75	204	22	10.78
2017-18	29.37	0.88	2.99	199	27	13.56
2018-19	55.01	6.01	10.92	281	41	14.59
Mean ±SD	34.33 ± 10.92	1.61± 1.67	4.26±2.68	204.2±42.74	28.5±9.24	13.85±2.77

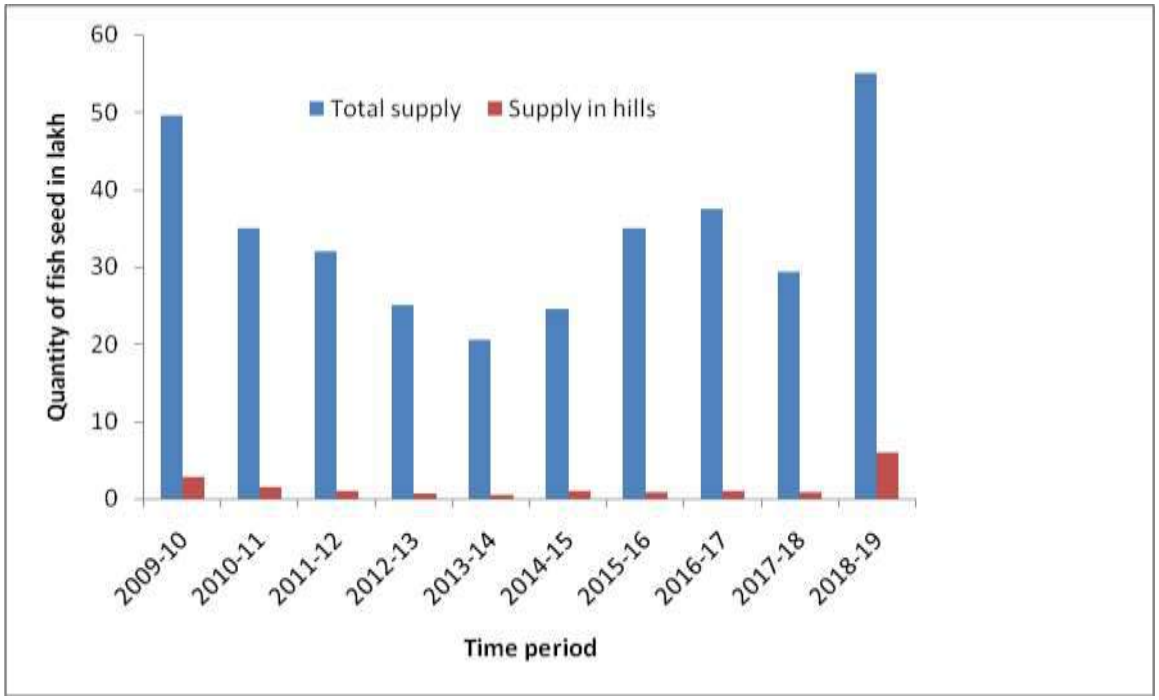

Figure 1. Annual fish seed supply from Fish Hatchery, Pantnagar

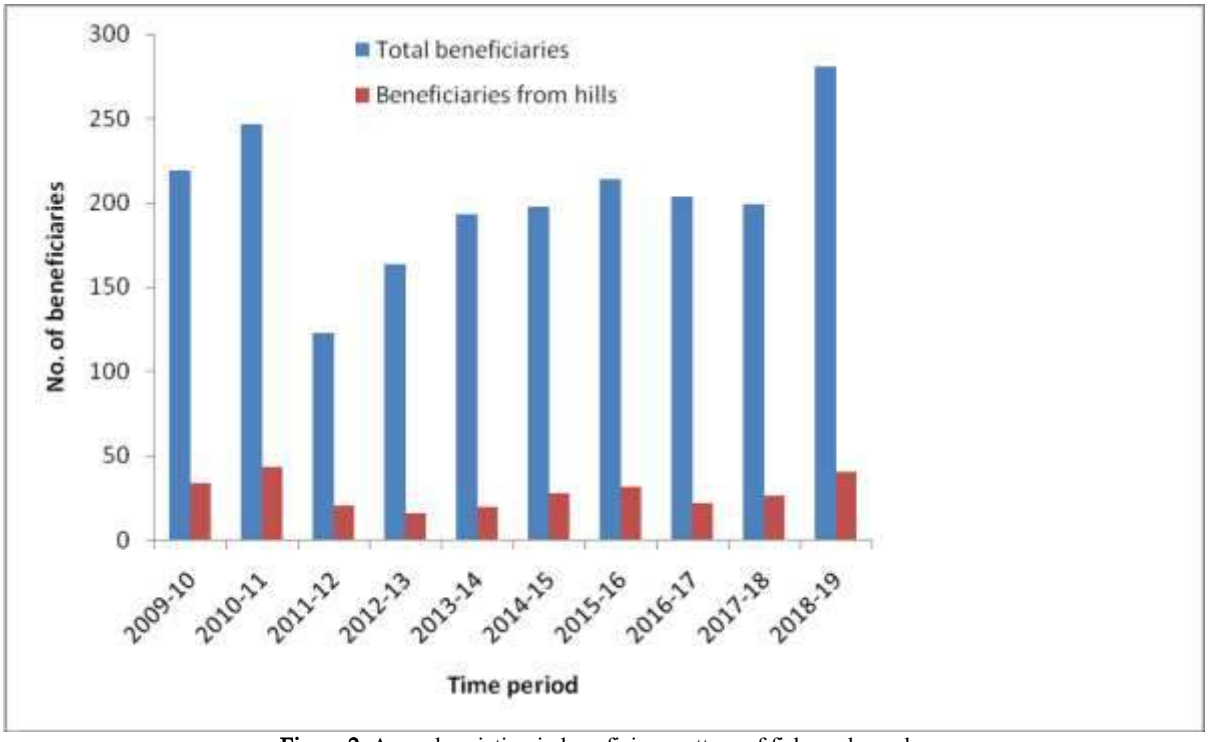

Figure 2. Annual variation in beneficiary pattern of fish seed supply

The adoption of fish culture in hilly region of Uttarakhand is increasing day by day may be due to earning more profit from fish culture, production of nutritious food for large fish eating population (84-91%) and subsistence crop production from non profitable agriculture (Muruganandam *et al.,* 2014). It has been reported that incubation, rearing and transportation of fish seed can result in high losses due to poor management (Jha *et. al*, 2015). In the present investigation, minimum losses have been recorded by adopting standard procedure during fish seed production and transportation, . The total number of fish seed beneficiaries during the study period varied annually from 123 (2011-12) to 281 (2018-19) with mean value of 204.2± 42.74 while in hilly region their number ranged between 16 (2012-13) and 44 (2010-11) with

mean value of 28.5 ± 9.24. The percent share of hilly region beneficiaries varied from 9.76 (2012-13) to 17.81 (2010-11) with average share of 13.85 ± 2.77%. The supply of seeds of specific carp fish in hilly region during different months depends on their availability and choice of the beneficiaries (Jha *et al.*, 2019). Also size of the pond and stocking density affect the quantity of fish seed procurement. In hilly region, generally, farming of the carps has been done in small sized ponds (0.01- 0.03 ha) (Singh, 2016). An ideal fish stocking density would be between 0.5 and 2.5 fish/ m^2 of water spread area in ponds for carp farming, depending upon size of seedlings (Jhingran, 1991). Most of the farmers prefer to stock large number of fish seed over carrying capacity with belief that stocking more fish seedlings leads to higher production. But stocking beyond carrying capacity of culture system, waste assimilation capacity, nutritional status *etc.* would only be counterproductive (Muruganandum *et al.*, 2014). The supply of grass carp seeds in hilly region varied from 200 (December 2017-18) to 137200 (May 2018- 19) during the experimental period while during November, January and March seeds were not supplied (Table 4 and figure 3). Compared to other fishes, the monthly demand of silver carp was less which varied from 150 (November 2013-14) to 20000 (June 2016-17) with zero demand during January and March (Table 5 and figure 4). Amur common carp is highly demandable fish in hilly region which monthly supply varied from 20 (October 2010-11) to 30000 (May 209-10) with nil supply during January (Table 6 and figure 5). Many farmers also stock Indian Major carps in their pond/ tanks which monthly supply varied from 20 (November 2013-14) to 250000 (May 2018-19) (Table 7 and figure 6). The present study revealed that fish farming is adopted by the farmers of all the hilly districts of Uttarakhand. The district wise annual seed supply trend shows that Champawat purchased highest quantity of fish seed (68800 during 2009-10) while minimum fish seed was obtained by the farmers of Chamoli district (Only 200 seeds during 2012-13) (Table 8 and figure 7). As per recorded data, it is clear that Kumaon region is doing better in fish culture than Garhwal region.

The production volume of fish across the state has gradually increased over last decade from about 3160 tonnes during 2009-10 to 4320 tonnes in 2018-19 (DoF, 2020). It may be due to availability of quality fish seed in required quantity and adoption of fish farming in scientific manner. Though the availability of fish for inhabitants of Uttarakhand is very poor (0.7 kg/ capita/ year) compared to national average (6.46 kg/ capita/ year) (Jayan, 2021) which has to be enhanced by adopting innovative fish farming technologies *viz.* fish farming in recirculatory aquaculture system, race system, biofloc system, fish production in cages *etc.*

4. Conclusion

The State Uttarakhand is endowed with excellent inland water resources in the form of rivers, lakes, reservoirs, ponds *etc.* which provide conducive ecology for culture and capture of freshwater fishery. The ponds located in lower hills (Shivalik hills) are used mainly for composite carp culture especially the grass carp, silver carp and amur common carp. Technology developed for the breeding and larval rearing in climate of mid Himalayan region has a positive impact on the employment generation in these regions since the technology was taken as hot cake among the farmers in some areas of hills. There is a great scope for disseminating this promising technology in sub to mid Himalayan belt in order to upgrade the socio- economic conditions of inhabitants. To get maximum fish production from their ponds, most of the farmers try to purchase fish seed from reputed fish hatchery. Fish Hatchery College of Fisheries, Pantnagar is the first choice of Uttarakhand farmers. The present study revealed that the farmers from most of the Uttarakhand districts as well as from nearby places of Nepal procure the required quantity of fish seed from Pantnagar in required quantity and their number as well as seed quantity is increasing day by day. The adoption fish farming by large number of farmers in the state will help in increasing fish production of the State and upgrade the socio-economic conditions of the inhabitants with food and nutritional security.

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Table 4. Monthly supply of Grass Carp seed

Year	Month											
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
2009-10	0	64000	9700	20000	1450	0	0	0	0	0	0	0
2010-11	27000	500	500	62300	9000	200	1000	0	0	0	1000	0
2011-12	0	1000	0	0	4100	1500	0	0	0	0	0	0
2012-13	0	3000	36200	0	3000	6000	2500	0	0	0	0	0
2013-14	0	0	0	250	2000	250	6100	0	500	0	0	0
2014-15	0	3900	500	5500	1000	62006	12000	0	900	0	0	0
2015-16	5000	18000	13500	3500	2250	2000	0	0	0	0	0	0
2016-17	0	8500	100	15000	0	0	2500	0	0	0	840	0
2017-18	0	6550	2840	2000	1000	2000	2500	0	200	0	0	0
2018-19	0	137200	36500	20500	2500	1000	2300	0	0	0	0	0

Table 5. Monthly supply of Silver Carp seed

Year	Month											
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
2009-10	0	0	0	10000	250	0	0	0	0	0	0	0
2010-11	0	0	0	0	1000	100	780	0	0	0	1000	0
2011-12	0	0	0	0	0	1000	0	0	0	0	0	0
2012-13	0	100	0	0	600	0	0	0	0	0	0	0
2013-14	0	0	0	250	2250	250	0	150	500	0	0	0
2014-15	0	1600	500	13000	0	2000	0	0	0	0	0	0
2015-16	0	0	0	1500	1250	2000	0	0	0	0	0	0
2016-17	0	13000	20000	3000	0	4000	0	0	0	0	660	0
2017-18	0	0	660	0	0	0	0	0	0	0	0	0
2018-19	0	0	0	0	0	0	150	0	0	0	0	0

Table 6. Monthly supply of Amur Common Carp seed

Year	Month											
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
2009-10	26000	30000	28350	5000	0	0	0	0	0	0	0	17500
2010-11	21000	1000	200	300	770	0	20	0	0	0	1026	0

2011-12	11500	16250	0	0	0	0	0	0	0	0	0	0
2012-13	0	250	0	0	0	0	0	0	40	0	0	1000
2013-14	2000	0	0	250	500	350	0	150	500	0	0	0
2014-15	5000	2300	0	2020	50	100	0	0	0	0	0	500
2015-16	3000	4000	240	44	0	0	0	0	0	0	0	100
2016-17	12200	4700	1500	0	0	0	28	0	0	0	1000	0
2017-18	500	0	0	32	0	0	0	0	0	0	0	1750
2018-19	4500	5500	4750	2400	0	0	50	0	0	0	0	0

Table 7. Monthly supply of Indian Major Carp seed

Year	**Month**											
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**March**
2009-10	0	40000	0	0	6300	14500	5000	0	0	0	200	2000
2010-11	0	0	0	5000	8500	4000	9000	0	7250	0	3500	1000
2011-12	0	0	0	0	0	1000	8050	1000	22000	0	0	0
2012-13	0	0	0	0	10000	4000	1000	0	0	0	0	0
2013-14	0	0	0	0	2000	19600	4000	20	0	0	0	0
2014-15	0	0	0	1500	1500	7500	0	0	0	0	0	0
2015-16	0	0	0	1000	1000	1000	3900	0	0	0	0	0
2016-17	800	2500	11000	2000	0	800	4150	0	0	600	0	0
2017-18	0	0	0	56000	4000	4000	3550	0	0	0	0	0
2018-19	0	250000	125000	3000	1000	2000	2700	0	0	0	0	0

Table 8. District wise fish seed supply in hilly region

Year	**District**									
	Nainital	**Almora**	**Bageswar**	**Champawat**	**Pithoragarh**	**Pauri**	**Tehri**	**Dehradun**	**Rudraprayag**	**Chamoli**
2009-10	15450	20000	10000	68800	18500	0	0	0	1000	77000
2010-11	46230	18276	2150	20450	19510	4650	0	0	30000	60
2011-12	8000	8050	4000	22000	24850	0	0	0	0	0
2012-13	19840	700	2350	19100	23000	0	1500	0	0	200
2013-14	24700	6100	0	2000	4750	0	0	3300	0	0
2014-15	7070	14000	1000	74506	20000	2300	0	0	0	0
2015-16	13384	8200	2000	5600	40500	100	0	0	0	0

2016-17	22408	11120	800	6500	37500	600	0	0	0	24000
2017-18	5182	11200	1200	7050	6200	0	0	0	0	0
2018-19	24950	9700	1000	5900	41000	7000	0	0	0	0

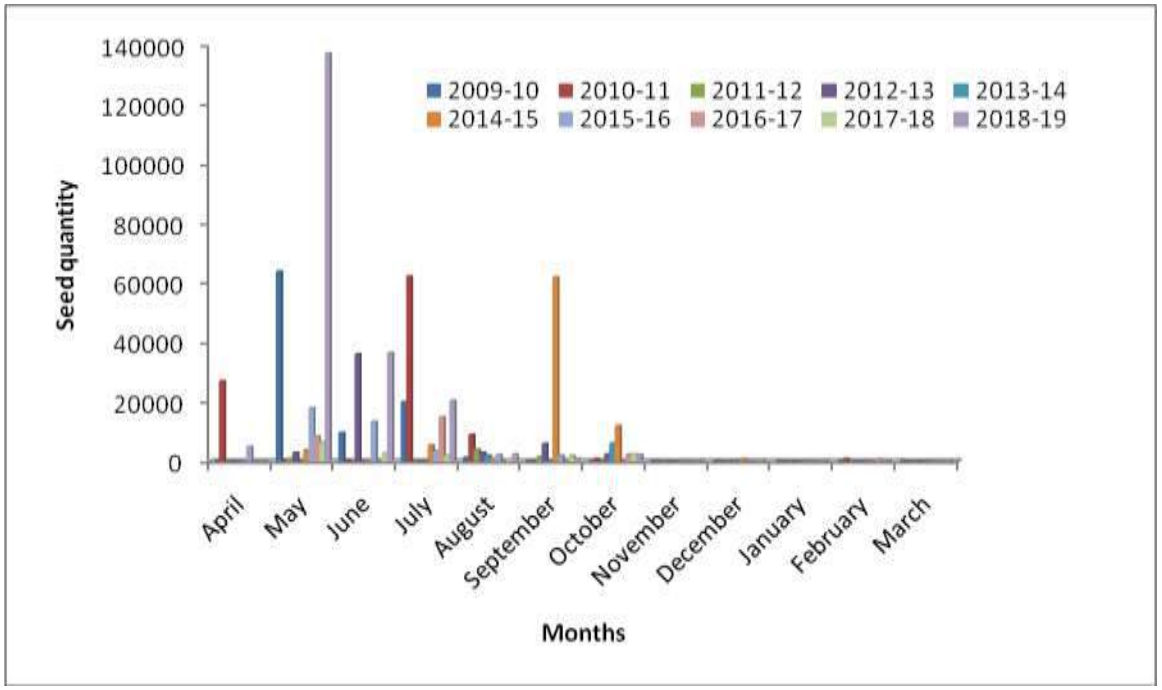

Figure 3. Monthly seed supply of grass carp

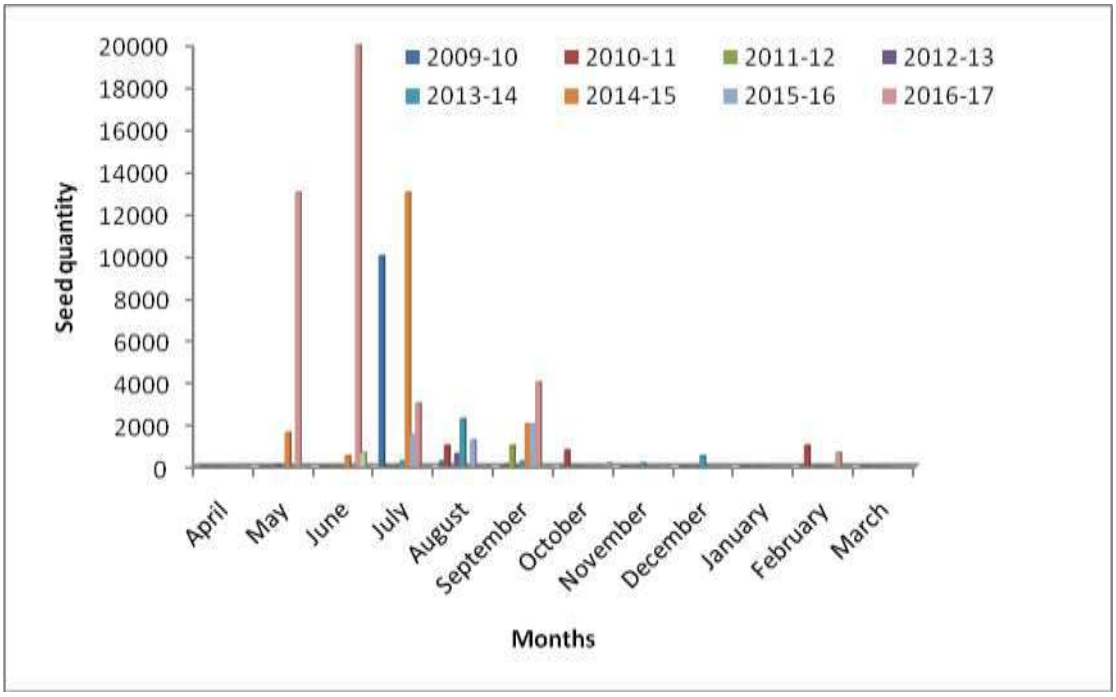

Figure 4. Monthly seed supply trend of silver carp

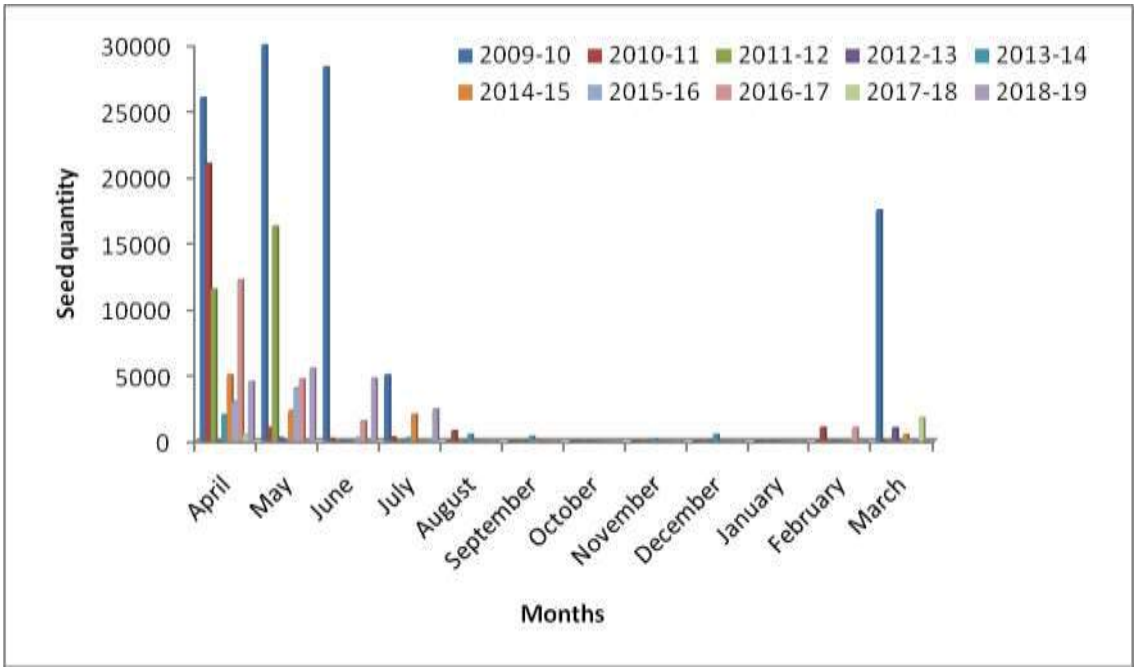

Figure 5. Monthly seed supply trend of amur common carp

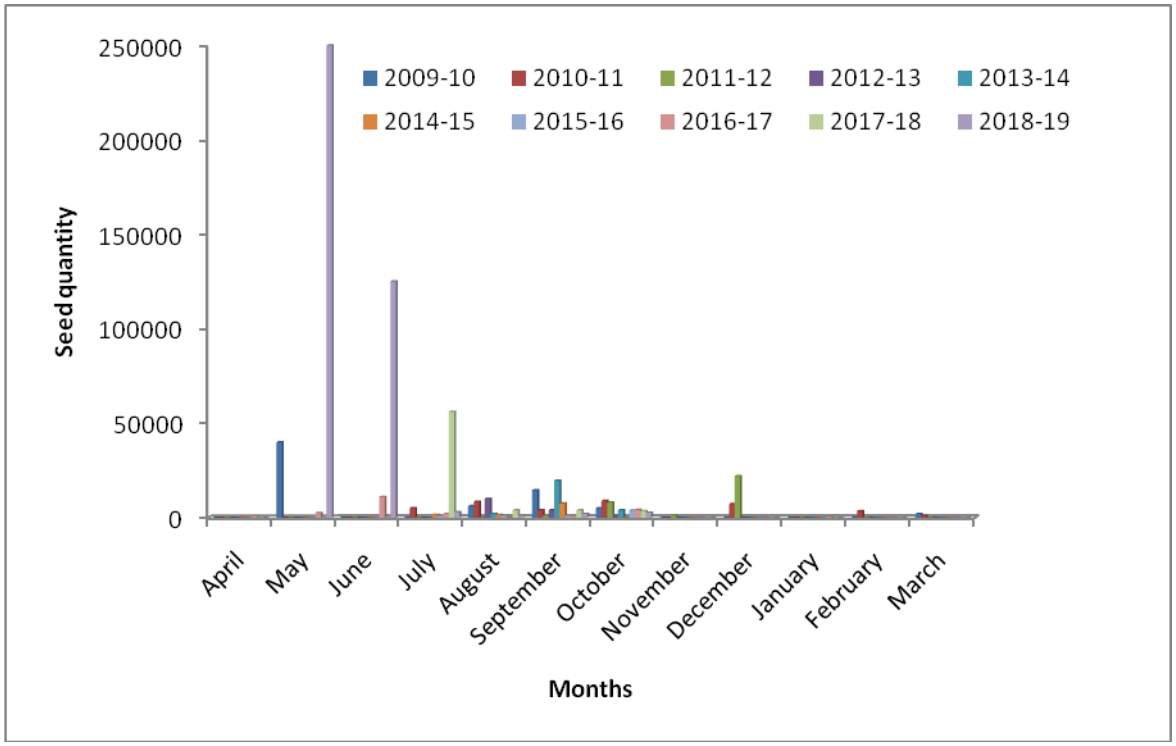

Figure 6. Monthly seed supply trend of Indian major carps

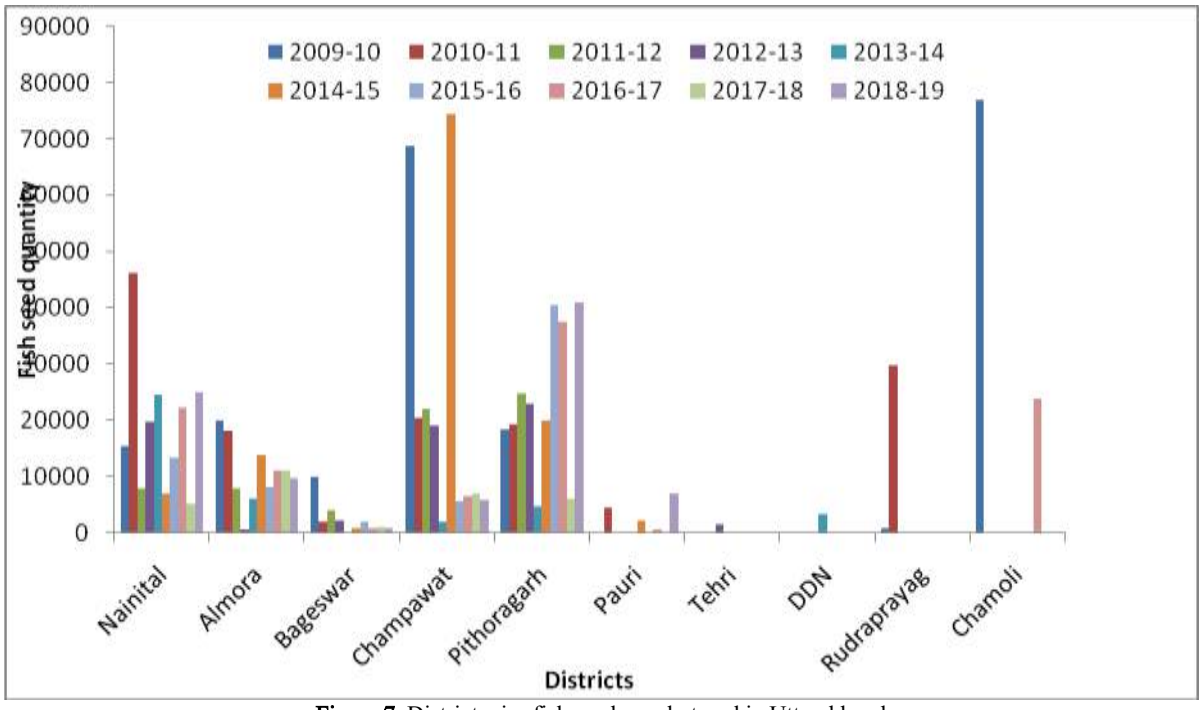

Figure 7. District wise fish seed supply trend in Uttarakhand

6. References

Bisht Anil, Shalini Anand, Bhadula Shushil, Pal DK (2013). Fish seed production and hatchery management: A review. *New York Science Journal,* 6 (4): 42- 48.

De Silva, Sena S and Anderson Trevor A (1995). Fish nutrition in aquaculture. *Chapman & Hall,* 319 p.

DoF (2020). Handbook on Fisheries Statistics 2020. *Fishery Survey of India,* 176p.

FAO 2020 (2020). The state of world fisheries and aquaculture: Sustainability in action, *FAO,* 206 p.

Ghosh Ambalika; Mahapatra BK, Roy Ajeet Kumar (2017). Relationship between fish seed and inland fish production of West Bengal, India. *SM Journal of Biometrics & Biostatistics,* 2 (2): 1013.

Gupta, SD, Rath SC (2011). Carp breeding and seed production, *In: Handbook of Fisheries and Aquaculture*, *by* Ayyappan, S., Moza, Usha, Gopalakrishan, A., Meenakumari B., Jena K. J., and Pandey A. K. ICAR, New Delhi, pp. 358-379.

IMD (2015). Climatological normals 1981-2010. *India Meteorological Department*, 589-590.

Jayan TV (2021). How much fish is eaten in each state in India? *The Hindu (Business Line ,* 26 July, 2021.

Jha DK, Bhujel RC, Anal AK (2015). Carp seed survival in private hatcheries of Nepal. *Nepalese Journal of Aquaculture and Fisheries,* 2 :65- 75.

Jha DK, Bhujel RC, Anal AK (2019). Survey on carp seed production in private fish hatcheries of Nepal. *ZOO- Journal,* 5: 7-15.

Jhingran VG (1991). Fish and fisheries of India. *Hindustan Publishing Corporation, India*, 727p.

Kandpal K (2013). Present scenario of agriculture in Uttarakhand. *Agropedia. agropedia.iitk.ac.in/content/present-scenario-agriculture-uttarakhand.*

Kumar K, Tiwari A, Mukharjee S, Agnihotri V, Verma RK (2019). Water at a glance: Uttarakhand an assessment of water scarcity. *Technical report, G.B. Pant National Institute of Himalayan Environment and Sustainable Development,* Almora, 35 p.

Maurya AK, Upadhyay AD, Prasad L, Khan S (2018). Trend analysis of fish production in Uttar Pradesh, India. *Journal of Entomology & Zoology Studies,* 6 (4): 180-184.

Mishra, A, Sharma AP (2020). Present status and future prospects of fisheries in Northern India. *In: Souvenir of the conference, "Ecosystem Health and Fisheries of Indian Inland Waters: Multiple Stressors, Management and Conservation*" organized by College of Fisheries, G.B. Pant Univ. of Agric. & Tech., Pantnagar in collaboration with ICAR- CIFRI, Barrackpore and AEHMS, Canada during 17- 19 February, 2020. Pp 25-31.

Murugandam M, Pande RK, Sharda VN, Mishra PK, Raizada A (2014). Myths, perceptions and knowledge of farmers on basics of fishes and fish farming in western Himalayas: A review of realities. *Indian Journal of Traditional Knowledge*, 13 (1): 70- 86.

Roy ML, Chandra N, Kharbikar HL, Joshi P, Jethi R (2013). Socio- economic status of hill farmers: An exploration from Almora District in Uttarakhand. *International Journal of Agriculture and Food Science,* 4 (2013): 353-358.

Sharma AP, Mishra A (2009). Fisheries in Uttarakhand: Status, prospects and development. In: *Agriculture in Uttarakhand Hills by B.S Bisht and D.P. Singh.* Directorate of Experiment Station, GBPUA&T, Pantnagar. 217- 226.

Sharma AP, Mishra A (2018). Uttari Bharat Men Machhli Palan. *G.B. Pant Univ. of Agric. & Tech., Pantnagar, ISBN No: 978-81-935354-2-4*, 126 p.

Sharma D, Akhtar MS, Singh AK (2018). Coldwater fisheries research and development in India. *In: Aquaculture in India edited by S.D. Tripathi, W.S. Lakra and N.K. Chadha, Narendra Publishing House,* 93- 133.

Singh, AK (2016). Fish diversity of Himalayan region, India for sustainable development. *Uttar Pradesh State Biodiversity Board*, pp 140-144.

Statista (2021). Fish volume across Uttarakhand FY 2009-2018. *Statista Research Department,* 2021.

Tiwari JP (2008). Five decades of Pantnagar. *G.B. Pant University of Agriculture and Technology, Pantnagar,* 316p.

Tuteja U (2013). Agriculture profile of Uttarakhand. *Agricultural Economics Research Centre, University of Delhi, Delhi,* 30p.

Upadhyay V (2021). Thanks to Uttarakhand government's initiative, fishermen pick their catch in treasured water. *The New Indian Express,* 20 June, 2021.