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Agrotechnological Options for Upscaling Productivity of Underutilized Wetlands Under Impending Climate Change Situations: A Review

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ABSTRACT

This review article scrutinizes some of the vibrant technologies developed/ refined/ adopted to improve agricultural system productivity of underutilized wetlands/waterlogged/lowland areas in the Eastern Indo Gangetic plains. Efficient agronomic research and technological development for improving wetlands productivity in eastern region are the only options to feed our people, to generate income and employments under this difficult situation. These tested and refined technologies are not only capable of improving wetlands ecosystem productivity in a sustainable manner but are equally efficient in minimizing the outbreak of insects and disease pests. Among different approaches for enhancing productivity of wetlands Makhana based cropping system is an efficient approach. Important agrotechnology developed and refined for Eastern Region conditions are briefly discussed in this article.

Keywords: Fox nut (Euryale ferox), Makhana, Nutritional and Medicinal value, Adjacent composition

INTRODUCTION:

Eastern Indo Gangetic Plains is currently facing problem of feeding ever-increasing population under the climate change scenario. In India agricultural researches over the past few decades have led to a substantial increase in production per unit area but due to rapid growth of population, per capita land availability is gradually decreasing and thus putting agriculture under pressure to meet the growing demand for food (Swaminathan, 1991).The present system of farming to utilize land and water resources may not meet the projected food needs for the 21st century and therefore, there is an urgent need to find sustainable farming system, exploiting soil and water resources more intensively (Verma, 2006).Eastern Region is fortunate in having plenty of water resources, even though many parts of the country are facing acute shortage of water. Substantial increase in crop production (up to 5 to 8 times) is possible using a mix of technology option and optimum rainwater management practices on farming system approach. In north Bihar, there are biologically diverse and productive wetland ecosystems, which include fresh water marshes, swamps, flood plains (chaurs) and ox bow lakes (mauns) (Dehadrai, 1994 and Verma,1995).Such wetlands rapidly deteriorate due to heavy weed infestation, seepage and evapotranspiration and become derelict. As they remain mostly unutilized, these wetlands tend to transform to land in course of time (Hora and Pillay, 1962).The agricultural productivity of the state, which has declined considerably in the last few decades, is likely to increase manifold with the effective utilization of wetlands. However, proper scientific management offer immense scope for integrated fish farming attendant with social, economic, and ecological benefits (Verma, 1994).Integrated fish farming is a diversified and coordinated way of farming in which crop production, horticulture and animal husbandry supplement fish as the main product. In this complementary farming one practice does not affect another and yet both practices benefit mutually. The vast stretch of flood plain wetlands in Bihar can be turned into an agricultural gold mine, if it is managed effectively and put to appropriate use. Wetlands ('*Tal*' lands), are the interphase between land and water, are usually located at the Eco tones, transitional between dry terrestrial ecosystem and permanently wet ecosystems. Wetlands comprise 6.4 per cent of the world's total land area. North Bihar has sizeable area under wetlands. Water is the prime mover in agricultural development in rainfed agriculture. For better use of wetlands in agriculture in water-limited environments, Makhana based cropping new approaches in wetlands use. Among different approaches for enhancing productivity of wetlands Makhana based cropping system is an efficient approach. Water use efficiency of wetlands can be increased by two ways, either by increasing yield or by saving water. Water use efficiency is affected by a number of factors like climatic conditions, edaphic factors, nature of plant and agronomic practices. There are various techniques to increase productivity of wetlands in the Eastern Indo Gangetic Plainsecosystem. Many options to improve water use efficiency are available and the target is to produce more biomass with minimum possible amount of water. Suitability of any crop and their variety is solely depending upon the purpose for they are developed and should be equally accommodative with the location specific agroclimatic conditions. Makhana plants could thrive well in ponds with water depth of one metre or even less. Shallow plots are now being utilised for rotational cultivation of Makhana with potato or wheat as an arable crop in the same plot (Jha 1999). Ensured water supply could help carry out this endeavour on a larger scale. Farmers take advantage of this option by transplanting young Makhana plantlets during late March or early April. They plant a wheat variety early during December by draining out the water and harvesting the crop latest by March end. Farmers in Kosi belt in Saharsa, Supaul, Madhepura, Katihar, Purnea, Araria and Kishaganj districts are trying this option in a better way. With ground water table relatively higher in this region, it ischeaper for them to ensure irrigation with the help of bamboo borings. According to Singh *et al.* 2012, there is need to mitigate imminent climate change to enhance of agricultural system productivity through efficient carbon sequestration and improved production technologies. Makhana is one of the prominent nutritious aquatic crops for efficient mitigation imminent climate change and to enhance water bodies productivity (Singh *et al.*, 2012).*Euryale ferox* is the only species of the genus. It is commonly called Fox nut, Gorgon nut, Prickly water lily. In Hindi and Bengali- Makhana, Telegu- Mellunipadmamu, Uriya-Kuntapadamu, Punjab - Jewar. It is a stemless, prickly, acquatic herb, rootstock short and thick (Singh, 2003).The leaves are about 4 different types appearing in the chronological order of sinuate, hastate, sagittate and orbicular types. The first three sets of leaves are not prickly but the last set of leaves is prickly. The orbicular leaves by their perpetual growth attain larger, heavy, orbicular, corrugated structure with spines (Singh, 2003).Leaves are alternate, round, large (1 -2m) and floating in nature. These are born on a 3-5 feet long petiole. The colour of upper surface appears to be green while the lower one looks deep purple. Both surfaces are covered by numerous thorns(Kak, 1985).The flowers are solitary, submerged, and epigynous with four persistent, thorny sepals inserted on the torus above the level of the ovary, together with many seriate petals. Most flowers are cleistogamous, but chasmogamous flowers may also be produced. The inferior, multicarpellary ovary develops into a spongy berry like fruit which is densely prickly, the size of an orange, and contains 30-40 pea size seeds with hard black seed coat and a mucilaginous aril. The pulpy aril keeps the seeds floating for a few days after they dehisce, before they finally settle down to the bottom of the water (CSIR, 1952; Sokolov, 1952; Mishra *et al.*, 2003; Verma *et al.*, 2003; Das *et al.* 2006; Verma *et al.*, 2010 and Kumar *et al.*, 2011). Being the non-cereal food, Makhana is

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an ideal staple food of devotees during their religious fast (Mishra *et al.*, 2003).The region is characterized by socioeconomic constraints like small and fragmented farm holdings, lowest per capita availability of land, inequitable agrarian structure, resource poor farmers, and poor infrastructure facilities like roads, communication power supply, storage and marketing (Singh *et al.*, 2011). The characteristic feature mentioned all together lead to poor system productivity of agricultural as a whole including crop production. Unfortunately, untimely heavy rainfall poses a potential threat to agricultural production and productivity throughout the world and this might affect the crop yield, if suitable measures are not taken, crop. Keeping in view the potentiality of agronomic research and technological development for the agricultural development, this paper discusses different agronomic practices and agricultural technology developed for Eastern Indo Gangetic Plains under following subheads.

- Assessment of Agricultural Potential of Region.
- Application of developed agro-technologies.
- Agro-technologies developed and refined suitable for Region.
- System approach to combat eminent climate change.
- Contingency agronomy for flood and drought.
- Conclusion.

Assessment of Agricultural Potential of Region:

The Eastern Indo Gangetic Plains comprises of Eastern UP, Bihar, West Bengal, and plain parts of Assam (Anonymous, 2001-2011).The region suffers from various biophysical constraints such as water congestion and flooding during kharif (Singh *et al.*, 2012).Even though the region has rich rain (rainfall varies from 1025 mm to 2823 mm), surface and ground water resources they are grossly underutilized, and therefore a large proportion of the cultivated area does not receive any irrigation water. The land holding size of eastern region ranges from 0.3 to 0.5 ha, coupled with fragmented lands makes situation worse for application of any technology directly to the field. Owing to poor utilization of water resources, the cropping intensity in the region is low. There is a large gap between potential and productivity of major crops that can be improved by adopting efficient crop management technologies developed by several workers. Under these circumstances efficient agronomic practices based on sound footing on research and technological development often offer the opportunity to alter the environment, the condition of the host, and / or the behaviour of the causal agent, to achieve economic management of the disease. Integration of cultural practices, host resistance and pesticides or bio-control agents may be necessary to provide option for controlling economically important plant diseases (Singh *et al.*, 2011).

Application of Developed Agro-technologies:

About 70 per cent of land is prone to natural calamity viz., water logging, flood or drought etc. The highly fertile land, rich water resources, biodiversity and manpower can be used in an integrated manner in a farming system mode by recycling of wastes to secure high resource use efficiency and improved livelihood. The major research focus would be on multi-dimensional and multicommodity, multi-disciplinary research in a program matrix involving land and water management, crop management to take advantage of complementarities among them for improving overall resource productivity, resource or input use efficiency and livelihoods in the eastern region

(Singh *et al.,* 2012). Major thrust areas of agronomic research include (a) Conservation Agriculture (b) Nutrient management (c) Water management and (d) Climate resilience agronomy

Agro-technologies Developed and Refined for the Region:

The resource use efficiency at present level is poor due to lack of adoption of appropriate agronomic management practices developed through well planned efficiently executed research programme. Modern agronomic research must be dedicated on efficient natural resources management viz., sustainable land and water management, crop management to take advantage of complementarities among them (Singh *et al*., 2011). Agronomic research conducted and technologies generated for improving resource or input use efficiency and to improve overall resource productivity, and livelihoods in the eastern region are discussed below:

Nutrient Management:

Makhana is also known to incorporate huge amount of organic matter to the soil on account of having large leaf size and extensive root system. Soil organic matter serves as an important store house of nutrients, drives nutrient cycle, improves soil productivity, promotes water retention, and reduces erosion (Bulluck*et al.*, 2002). Under crop cultivation changes in soil organic matter status would determine the dynamics of alluvial soil quality of wet lands. In addition to makhana, the other components crops too would certainly add an appreciable amount of organic matter to soil. Jha and Dutta (2003) had reported about the chemical changes in soil under makhana plants growing in naturally existing ponds. However, the impact of various makhana-based-cropping systems on soil properties, yield attributes and yields of makhana and other associated component crops as related to seasons, particularly in silty clay loam soils of this region has not been studied till date.

Efficient resource conservation of wetlands ecosystem through crop diversification:

Intensification and diversification of cropping systems may allow improving the productivity and sustainability of agricultural production in the wetland areas, but the choices to be made require integrated assessment of various cropping systems. Crop diversification is one of the major components of diversification in agriculture. Crop diversification may be adopted as a strategy for profit maximization through reaping the gains of complementary and supplementary relationships or in equating substitution and price ratios for competitive products (*Singh et al.*, 2012). It also acts as a powerful tool in minimization of risk in farming (Singh *et al.,* 2011). These considerations make a strong case for farm/crop diversification in India. Crop diversification is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, and judicious use of land and water resources, sustainable agricultural development and environmental improvement. The ability of the region to diversify the cropping pattern for attaining various goals depends on the opportunities available for diversification, the need for diversification and responsiveness of the farmers to these needs and opportunities. The opportunities for crop diversification emerge from technological breakthroughs, changes in demand pattern, development of irrigation, availability of marketing infrastructure and new trade arrangements. The necessity for crop diversification arise on account of the need for (i) reducing risks associated with yield, market and prices (ii) arresting the degradation of natural resources and the environment and (iii) attaining national goals like employment generation, self-reliance in critical crop products and for earning foreign exchange.

Crop diversification by introduction of alternate production system:

Makhana based diversified cropping systems:

There is a large gap between potential and productivity of makhana crops in comparison of pond and field system. The crop growth period in pond system generally varies between nine to ten months; thus, farmers are unable to get more than one crop in a year. Furthermore, the yield potential of makhana grown in this (pond system) condition has been recorded only 11 to 16 q/ha (Mishra *et al.* 2003).Kumar *et al.*, (2011) showed that the cultivation of makhana could be done in general agricultural fields having clayey soils which are being used for rice cultivation. They also narrated that recently developed high yielding and early maturing makhana variety (Swarna Vaidehi) and cultivars of other crops hold enormous potential to produce more in irrigated areas than rice-wheat cropping system or rice, wheat and berseem alone, thus improving the total productivity of the cropping system. Therefore, crop diversification with higher biomass producing and fertilizer responsive cereals is of paramount importance in mitigating the problem arising due to low biomass producing rice-wheat or rice alone crops in the system. In addition to this, growing these cereals in combination with makhana would certainly have the potential to achieve a high grain yield per unit area and consequently greater land use efficiency than sole cropping, through efficient use of resources such as light, water and nutrients. This crop combination also helps to minimize risk of complete crop failure and bring stability of crop production under wetland condition. In the field condition the productivity of improved strain of makhana varied between 26 and 30 q/ha (Kumar *et al.*, 2012). They further reported that in field condition the crop growth period was of only four months. Hence, some other crops can also be taken in the same field after taking makhana crop. In this regard they had further developed some makhana-based-cropping systems such as makhana-makhana, makhana-rice, makhana-wheat, makhana-barseem and makhana-chestnut. As a result of this now a day's farmers are adopting the makhana-based cropping systems at their own fields in addition to natural ponds. Cropping systems developed in response to the demand for particular crops, soil nutrient status, soil physical structure and biotic completion and are constrained by available resources (including climate) and knowledge. The cycling pattern of nutrients with different cropping system has not yet been studied. Thus, for judicious application of nutrients to the associated crops needs to be studied well so that the makhana-based cropping systems such as makhana-makhana, makhana-rice, makhana-wheat, makhana-barseem and makhana-chestnut may be a substitute over the dominant rice-wheat cropping systems and fulfil the future demand of human and animal feed. This crop combination also helps to minimize risk of complete crop failure and bring stability of crop production under wetland condition [Kumar *et al.*, (2012)]. Semi deep region of the swamp (0.4 ha) yielded 500 kg makhana seeds, which were processed to get 200 kg pops of makhana (Table 2). On the basis of yield of makhana seeds, the present experimental swamp may be categorized under high yielding group (Verma, 1995). Dehadrai (1972) reported low yield of makhana seeds (320kg ha-1) in a derelict swamp. Verma et. al. (1996) reported high yield of makhana seeds (1400 kg ha-1) in a mixed culture of mangur, singhi, koi and murrels in a derelict wetland of north Bihar. Gupta *et. al.* (1998) reported higher rice yields by an average of 9.9 to 12.7% from integrated farming system. Halder *et. al.* (2003) observed high rice yields with an average of 4,116 kg ha-1 in Azolla integrated rice fish culture. Other crops obtained from the marginal land of the experimental swamp were wheat, mustard and kidney bean yielding 400 kg, 230 kg and 250 kg respectively (Table – 1). Out of which 1000 kg fodder (straw and husk) was supplied as agricultural by-products of marginal land crops whereas 11600 kg fodder was procured from the local market. Total milk production during the rearing period was 5040 kg (Table 2). The lowest input cost Rs. 8370 was incurred for aquacrops (fish and makhana) hence the highest net benefit of Rs. 33630 was obtained (Table-1). Verma *et al.* (1996) reported a net profit of Rs. 49171 ha-1 crop-1 from integrated culture of air breathing fishes with makhana. The highest input cost Rs. 36800 was incurred for the rearing of 3 milch cows. Borah *et al.* (1978) opined that livestock raising as apparently a cost intensive and low profit practice.The share of net profit of aquacrops (fish and makhana) to the total profit was 51.06 % whereas for dairying and arable crops (paddy, wheat, mustard and kidney bean) were 36.09% and 12.64% respectively. Wetlands are productive biotopes and an appropriate way to harness their potential may be to integrate aquacrops, agriculture and dairy farming in such ecosystem (Verma, 2006).

Table 1. Input cost and net benefit of integrated farming

Components	Input Cost (Rs.)	Qty. Produced (kg)	Gross Income (Rs.)	Net Benefit
(Rs.) Paddy	7650	1200 (Rice-980)	9800[a]2150	
Wheat +	1620	400	3200	1580
Mustard	1125	230 (M-oil-61)	2440[b]1315	
Kidney Bean	1750	250	5000	3250
Makhana	3370	500 (pops-200)	14000[c]10630	
Fish	5000	700	28000	23000
Dairying	36800	5040	60480	23680

Income from selling of - a : Rice (980 kg), b : Mustard oil (61 kg), c : Makhana pops (20 kg)

Integrated Farming System in Wetlands:

Location specific Integrated Farming System modules for small and marginal farmers:

Makhana (*Euryale ferox*) cum fish culture in water bodies of North Bihar, secondary reservoir for rainwater harvesting and productive utilization etc. are some other examples of multiple use of water in the Indo Gangetic Basin (Khan, 2010). This paper summarizes the results of different studies conducted on multiple use of water in the eastern Indo-Gangetic plains. Integrated fish farming is a diversified and coordinated way of farming in which crop production, horticulture and animal husbandry supplement fish as the main product. In this complementary farming one practice does not affect another and yet both practices benefit mutually. In Eastern Indo Gangetic Region, about 85 per cent of the farmers are small and marginal but sharing only 50 per cent of the land. The average size of the holding is 0.83 ha., For such prevailing situations, there is need to integrate agriculture, horticulture, fisheries and other allied enterprises like apiculture, sericulture, mushroom cultivation, livestock etc. which holds promise for this region for improvement in the livelihood of, small and marginal farmers. The high production of fish (700 kg in water area of 0.4 ha) during the culture period of 380 days was attributable to the supplementary feeding and the application of cow dung which not only fertilize the swamp but also helped to increase the population of plankton and acted as substratum for the growth and multiplication of microbial community (Table-2). Various workers discussed the augmentation of fish yield through supplementary feeding (Sinha, 1978, Patra, 1993) and manuring (Laha and Mitra, 1978; Patra and Ray, 1988; Patra, 1933; Singh and Sharma, 1999). A mixed culture experiment of mangur, singhi, and kawi yielded a gross production of about 1200 kg ha-1 in only 7 months (Dehadrai, 1972). Verma (1995) reported high fish yield of 3600 kg $ha^{-1}yr^{1}$ in a derelict wetland of north Bihar.

Table 2. Growth and Production of fish (Period of rearing: 380 days; Area: 0.40 ha)

Fish species	No. Production (gm)	No. stocked (kg)	Rate of harvested	Initial survival %	Final wt. (gm)	Growth wt. (gm)	increment
Silver carp (10%)	100	98	98	18	691	673	67.71
Catla (20%)	200	190	95	21	571	550	108.49
Mrigal (30%)	300	298	99	23	823	800	245.25
Common carp (30%)	300	295	98	30	763	733	225.08
Rohu (10%)	100	98	98	21	550	529	53.90

According to Khan (2010), successful integration of fish with makhana also offers multiple uses of water leading to greater efficiency in resource utilization and generation of additional food and income to the makhana- cum- fish growers. Additional income was generated by growing horticultural / vegetable crops on the bunds required to facilitate aquaculture and utilizing the stored water. Traditionally makhana is grown as a sole crop and water bodies are utilized for only seven months from February to August for growing makhana. Hence, efforts were made to maximize the productivity of water bodies through multiple uses of water by makhana- cum- fish integration and makhana and fish rotation with a goal to develop a model of integrated system of makhana cum fish culture in order to utilize the water body throughout the year. The integration of fishes with makhana resulted in fish yield of 1.83 to 4.03 q/ha and makhana seed yield of 10.64 to 20.63 q/ha as depicted in Table 3. The net income from integrated makhana based farming system ranged from INR 44, 686/ to INR 51,216 per ha/year. The successful integration of fish with makhana farming thus offer multiple uses of water, leading to greater efficiency in resource utilization and generation of additional food and income to the makhana –cum- fish growers. Integrating fish culture with makhana as concurrent crop and after makhana cultivation as a crop rotation is an improved production system that assures more return from water body than from cultivation of makhana alone. Besides this, for alternate income generation activities such as seasonal vegetables and fruits on the bunds of makhana ponds, vermi compost unit, poly houses for vegetable and fruit nursery, apiculture, poultry farming etc. are also being tried at farmer's pond for increasing water productivity as well as per unit area productivity (Table-3).

Table 3. Net Income from makhana –cum- fish farming through multiple use of water bodies.

Farmer	Pond Area (ha)	Makhana			Fish		Net Income (INR/ha)
		Gurri Producton (q/ha)	Lava Production (q/ha)	Net Income (INR/ha)	Yield (q/ha)	Net Income (INR/ha)	
Farmer-1	0.236	15.25	5.04	29,153	4.03	16,208	45,361
Farmer-2	2.909	20.63	6.81	32,313	1.86	13,436	45,749
Farmer-3	2.181	18.34	6.05	42,182	2.08	9,034	51,216
Farmer-4	1.090	10.64	3.51	24,367	1.83	20,319	44,686

Sources : Khan (2010).

Kumari (2009) opined that the wetland area which is generally waste land can be used as integrated fish farming with Makhana culture. This type of mixed culture will offer greater efficiency in resource utilization, will reduce risk by diversifying crop and will provide additional food and income. This system will be of special significance as it will improve the socio-economic status of weaker rural fisher community. Dearth of dissolved oxygen in the arched water surface makes it unsuitable for the growth of carp fishes. Progressive fish farmers, however, have now made it possible to derive maximum productivity by reaping the benefits of both catfishes as well as carp fishes. This is accomplished by leaving sufficient open spaces in the middle of the ponds. Makhana ponds could also be used for rearing fishes as well as for nursery ponds during September to January, which is the intervening period between the two successive Makhana crops (Verma and Jha, 1999; Ahmad and Singh 1997).

Contingency agronomy for flood and drought Boro rice for waterlogged area:

A number of agrotechnology has been developed by several workers for improving wetlands ecosystem productivity. The dead and abandoned courses form the stagnant channels, which are also utilised for cultivation of fish, deep water rice, boro rice Makhana and other aquatic eatables (Ahmad and Singh 1991, 1995; Datta Munshi et al. 1991, Dehadrai 1994; Jha 2000 etc.).

Integrated Aquaculture with Makhana:

Makhana growing water bodies are ideal reservoirs for air-breathing fishes like Singhi, Magur, Kawai etc., which derive their nutrition from the heavy organic detritus in the pond bottom. Leathery leaves during the peak growth period of the plants (between April to July) hardly leave any open surface to facilitate the dissolution of atmospheric oxygen to the pond water. Dearth of dissolved oxygen in the arched water surface makes it unsuitable for the growth of carp fishes. Progressive fish farmers, however, have now made it possible to derive maximum productivity by reaping the benefits of both catfishes as well as carp fishes. This is accomplished by leaving sufficient open spaces in the middle of the ponds. Makhana ponds could also be used for rearing fishes as well as for nursery ponds during September to January, which is the intervening period between the two successive Makhana crops (Verma et al. 1996; Ahmad and Singh 1997).

Other Suitable beneficial Aquatic crops Used for Edible Purposes:

In addition to Makhana, these wetlands produce a number of other plant products utilised as food. The most significant one is Singhara (*Trapa natans*), which has a high biological value (Jha 1999).Other products like Khubahi-ramdana (*Scirpus articulatus*), Bhent (*Nymphaea spp*.), Kamalgatta (*Nelumbo spp*.) kechuli (*Eichhornia crassipes*),are used in seed forms. Those utilised as underground forms include the Lotus rhizome, Kesaur, Saruk, Chichorh, Karahar etc. Leaves of Karmisaag (Ipomoea aquatica) and Sarhanchi (*Alternanthera spp*.) are utilised mostly as greensalong with fishes, molluscs, crab, prawn etc. as the wetland animal products. Plant products also serve as a promising source of protein, carbohydrates and minerals. This is because of pesticidal inflows from nearby arable fields along with the rainwater. Their amounts are often higher then the FAO/WHO standards and may prove a deterrent to the export feasibility of these products (Rai *et al.*, 2002).

Mithila Wetlands: Sites of Migratory Birds:

Flood plain wetlands like Kawar, Kusheshwarasthan, Baraila, Gogabeel, Khemait, Simribakhtiyarpur etc. are the prominent sites of resident and migratory birds in north Bihar. Wetland rice varieties and rhizomatous plants attract migratory birds during winter season, which in turn, make the water bodies more fertile with their excreta. Kawartal in Begusarai district, known for its rich biodiversity has been declared as the first Ramsar site in the state. On account of larger water spread area and the number of visiting birds, Kusheshwarasthan wetland also deserves the same treatment (Majumder et al. 1988; Yahya 1994; Sharma & Datta Munshi 1995; Jha and Chandra 1997 etc.).

CONCLUSION:

Eastern Indo Gangetic Plains region is characterized with unique physiography, socio economic condition coupled with fragmented land holding. Soil and water are the basic resources of agriculture. Despite the annual rainfall being adequate across all agro-eco systems, agriculture production suffers from excess runoff and water congestion causing floods on the other hand. For the sustainable crop production apart from improved agro-technology techniques like integrated watershed management, promoting conjunctive use of surface and ground water, improving water productivity through managing flooded, flood prone and waterlogged areas and acid soils management need to be perfected. Scientific and efficient management of these resources is the core of their sustainability. Ample scope of improvement in respect of crop production is available in the region as it is endowed with natural resources. Crop diversification through new crops can also play a vital role in increasing the income of rural household. Agricultural potential assessment based agro technologies suitable for the region discussed in this article along with system approach and efficient contingency planning is the key to succeed in the climate change era with respect to agricultural productivity system, as a whole. Now focus should be on technologies for small and marginal land keeping in the view the present climate change scenario to produce economically under expected frequent outburst of abiotic and biotic stresses.

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