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Considerations for Preparation of Questionnaire- An Initial Step in Intervening Cultivation Practices: A Review

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ABSTRACT

The crop cultivation practices and input portfolio are dynamic; hence moderation of them is a regular practice. The practices also need to be developed for different crops for their successful introduction in new (non-conventional) areas. This new introduction is needed due to climate change-induced variation in agro-climatic conditions and changes in crop adoption to environmental conditions. The systemic investigation into crop cultivation practices for their different aspects (economic, ecological, technical soundness, practical feasibility, adoption, discontinuation rate, market and policy-related interventions, *etc.*) is needed to suggest any modulation in cultivation practices and development of new practices. The North East Hill (NEH) region has a large diversity in agro-climatic conditions as well as agricultural practices followed. The NEH region is also recognized as having potential for an organic production system, natural farming system yield enhancement through crop cultivation practices modification, testing of new crops for their adoption, organic seed production, indigenous technical knowledge (ITK) documentation, traditional practices documentation and conservation of plant genetic resources. There is a need to document detailed procedures for system investigation in NEH region agricultural activities. The present review describes the point of consideration for systemic investigation of practices and enlists the variables for ranking of problems in these practices. The problem ranking can be used to calculate value-based coefficient and rank-based ratio. The detailed insight into different aspects of production practices can be achieved by following the point of consideration mentioned in this review. The data and/or information generated have scientific value towards initiating the process of modulation of crop cultivation practices and development of cultivation practices of newly introduced crops.

Key words: North East Hill region, Nutrient Management, Rank-Based Coefficient, Water Management.

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The crop plants have variation in their adoptability to different soil and climatic condition. Besides that, their growth and development also shows variation across different agro-climatic condition (Porter John and Semenov, 2005; Kukal *et al.,* 2018); hence cultivation practices are subjected to change across agro-climatic condition along with changes across crop and species. The variations in yield level and crop tolerance to different stress are deciding factors for crop adaptation. At the same time, different market and policy interventions influence crop cultivation/adoption in new area. The agronomic research relating to different interventions in cultivation practices and input addition is one of the most investigated concern across crop location and time (Bullock and Bullock, 2000; Oenema and Pietrzak, 2002; Dore *et al.,* 2008; Hegde *et al.,* 2012; Dang *et al.,* 2015) (Table 1). These cultivation practices and input addition such as crop nutrition management, biotic stress management (weeds, insect-pest and disease), water management, soil and tillage management are studied individually or together as comparison of different crop establishment methods or cultivation methods (Loganandhan *et al.,* 2013; Naresh *et al.,* 2013; Hobbs, 2021; Saurabh *et al.,* 2021) or production system (Reddy and Suresh, 2009; Stoop *et al.,* 2009; Long *et al.,* 2016).

The ultimate goal of these moderations is to enhance crop performance and to economies use of resources. The introduction of new crop or species of crop or variety is another intervention with order of significance and ease of introduction of variety > species > crop. The attempts such as demonstration, input distribution and field/institute visit will serve for introduction of variety (Patel *et al.,* 2013; Patil *et al.,* 2015; Brown *et al.,* 2020); while awareness programme, training, skill development workshops, expert advice and guidance during crop cultivation will be needed for the introduction of different crop species and sub-species. Introduction of new crop will be lengthy and tough task considering it's economic, ecological, technical and feasibility for adoption. Based on crop cultivation area/ zones, the areas are classified as traditional cultivation zone, conventional cultivation zone and non-conventional zone. The tradition cultivation zone indicates the area where crop is grown by ancestor or inherited across the generations. In such areas, crop may be in-situ or may be introduced centuries back with accountable species diversity observed in the area. The area with crop cultivation practiced over extended area at commercial scale with more or less uniform package of practices is considered conventional area. In case of non-conventional zone, crops are introduced in decade back and grown by following practices as per conventional area. This area/zone need considerable interventions with respect to moderation or development of new package of practices and input portfolio development. The practices followed in conventional area will serve as base and new practices will formulate through institutional efforts or by the stake holders themselves (By gathering information from different sources). Such introduction of crop and / or species in new area (non-conventional area) is done due to different factors such as need to produce more to meet demand (for food crop), policy and market interventions (commercial crops, orchards, exotic vegetables and fruits), climate change induced variation in crop adaptability in new environment and special need (organic seed production and catering export demand). The successful introduction of new crop/ species and variety need information on natural resources, input availability and their economics, present practices followed constraints as well as farmer/stake holders' opinion on cultivation of crop. Besides introduction of new crops, these exercises also useful for developing cultivation practices for indigenous crop grown as subsistence crops till date and scope for their yield improvement (Table 1).

Modulation of crop management practices

The modulation in weed management with the involvement of site-specific weed management through the use of different information and technology based tools and applications (camera-guided physical weeding, patch spraying and robotic weeding) were reported in Gerhards *et al.* (2022). The review of the use of micro-irrigation (sprinkler and drip) in rice by Mandal *et al.* (2019) showed a consistent and significant research outcome in terms of yield, economics and water saving. They also reported that, its adoption is constrained by a variety of factors from the agro-climatic condition, policy awareness and behavioral patterns of stakeholders towards the use of micro-irrigation. The modulation in tillage practices are described in terms of changes in conventional plough based tillage to different variables of conservation tillage (Subbulakshmi *et al.,* 2009) and system of crop intensification (Abraham *et al.,* 2014; Adhikari *et al.,* 2018). The various (mostly positive) impacts of conservation tillage on natural resource, their productivity and sustainability (Busari *et al.,* 2015; karunakaran and Behera, 2015; Bhatt, 2017; Jia *et al.,* 2019; Ojah and Bhattacharjee, 2021) were reported widely. This indicates their potential and scope for research on such tillage modulations. The developing new plant type/ varieties and seed replacement ratio (Singh *et al.,* 2016; Singh *et al.,* 2020) are considered important indicators of the modulation of plants in agriculture. Such modulation in cultivation practices demands the investigation of the possible interventions in cultivation practices in all three zones.

The detailed region-wise information/database about agro-climatic variables is needed for- a) Modulation of crop cultivation practices and input portfolio, b) development of new practices for introduced cropsand c) analyzing the varied level of potential of each area towards crop production/introduction. This information needs to be collected systemically and (no need) from different stakeholders. This process of information collection can be made easy by preparing systemic questionnaire-based information collection. The NEH region has wide variation in agro-climatic conditions and also remains least touched by modern agrochemical-based developments in agriculture. Further, sections address the points of consideration for questionnaire preparation. The practices followed in agriculture in the NEH region are varied to a great extent and there is scope for their moderation. Hence, an attempt has been made to discuss the point of consideration for the collection of information.

Introduction to north east hill region

The North East Hill (NEH) region is unique among different agricultural zones/areas in India. The agro-climatic conditions in NEH region is characterized by high (variable) rainfall (Prokop and Walanus, 2015; Govindasamy *et al.,* 2021), sharp changes in soil topography, richness of soil in organic carbon (Choudhury *et al.,* 2016), soil acidity (Mandal *et al.,* 2019), variation in soil nutrient status (Choudhury *et al.,* 2021) and extended soil erosion (Saha *et al.,* 2012). The agriculture in the NEH region is characterized by organic production mode, shifting cultivation (Ray *et al.,* 2021) use of indigenous technical knowledge (Singh and Gupta, 2002), use of local/ traditional varieties/ landraces, lack of adaptation of new technology and low seed replacement ratio, higher involvement of animal component, the farming system rather than cropping system-based approach, involvement of horticultural plants/ crops and agroforestry as a component of farm. There is a large diversity of crops grown in the region; while area under their cultivation and the practices followed for their cultivation differ significantly from the recommended practices. Hence, information collection on the present practices is needed. This can be addressed by questionnaire preparation by taking all points into consideration as given below for each crop cultivation practices separately.

Point of consideration for questionnaire preparation

Criteria for selecting of stakeholders/ farmers/crops

- The stakeholders should be selected from all five groups of land holding *viz.*, marginal, small, semi medium, medium and large.

Table 1: Modulation of crop management practices and their impact on soil, plant and water.

Particulars of new crops/varieties /species/practices introduced	Area	Results	References
Use of zinc solubilizing rhizobacteria in wheat for biofortification of wheat	Eastern Uttar Pradesh, India	*Bacillus tequilensis* (CRS-38) and *Paenarthrobacter nicotinovorans* (CRS-30) inoculation significantly increased growth and yield attributes of wheat as well as zinc concentration in the shoot and grain of wheat. The zinc concentration of 54.25 µg g^{-1} was recorded in wheat grain having inoculation of *Bacillus tequilensis*.	Yadav *et al.* (2022)
Use of micro-irrigation (drip) in rice to reduce the water use in the rice production system (modulation of water scheduling and methods of irrigation)	Madhya Pradesh, India	The increase of yield by 1.91 to 3.03 Mg ha^{-1}, net returns by 1409 to 2111 US \$ ha^{-1} and B:C ratio 2.16 to 2.81 due to drip irrigation by keeping the dripper at 20, 30 and 40 cm spacing within row over SRI methods of rice cultivation. Significant increase in plant height, root length and yield attributes (effective tiller m^{-2}, grains per panicle and panicle length and weight) with drip over SRI methods was also reported.	Rao *et al.* (2017)
Comparison of conventional and conservation tillage in rice-based cropping system	Bihar, India	The increase in grain yield of rice (9.3-20.6%), maize (10.8-11.8%) and wheat (18.4-22.6%) in zero tillage based cropping system over conventional tillage was recorded. The increase in monetary returns was Rs. 48,164 ha^{-1} in zero tillage direct seeded rice followed by zero tillage wheat/maize. In case of zero tillage transplanted rice followed by zero tillage wheat/maize and no tillage transplanted rice followed by zero tillage wheat/maize net returns were higher by of Rs. 35,800 and Rs. 25,632 per ha over conventional system.	Nandan *et al.* (2018)
Comparison of conservation tillage with convention tillage in rice-rice cropping system	Tripura	A significant increase in total organic carbon, total organic carbon stock and carbon sequestration rate with zero tillage over conventional tillage was year study. Combination of integrated reported in three nutrient management (25% N through green leaf manure+60 kg N, 9 kg P, 17 of potassium (K), 2 kg boron and 5 kg Zn ha^{-1} + residue retention (30%)+ cellulose decomposing microorganisms) significantly increase rice yield and system yield in all three studied years.	Yadav *et al.* (2017)
Use of allelopathic crop extract (Sorghum, sunflower and rice) with herbicide for control of weeds in rice (@ 15 liter/ha tank mix with 1/3rd or 2/3rd of the recommended dose of different herbicides).	Pakistan	Reduction in dry weight of weeds (barnyard grass, flat sedge and crowfoot grass) by 66%, 71% and 76% due to application of allelopathic extract with ½ recommended dose of butachlor (600 g a.i. ha^{-1}), pretilachlor (313 g a.i. ha^{-1}) and ethoxysulfuronethyl (15 g a.i. ha^{-1}), respectively. Similarly, increase in yield of rice by 61% 59% and 41%, respectively due to their application.	Rehman *et al.* (2010)
Three crop establishment methods (conventional puddled transplanted rice (PTR), system of rice intensification (SRI) and aerobic rice system (ARS) followed by three crop establishment methods of wheat (Conventional drill--sown wheat (CDW), a system of wheat intensification (SWI) and zero tillage wheat (ZTW)	New Delhi, India	Increase in net returns in ARS followed by ZTW was of Rs. 3,416-7,737 ha^{-1} over PTR-CDW and Rs. 7,864-12,376 ha^{-1} over SRI-SWI. System nitrogen, phosphorus, potassium and zinc uptake in ARS-ZTW was 15.7-17.6 kg ha^{-1}, 0.7-0.9 kg ha^{-1}, 7-9.8 kg ha^{-1} and 13.5-23.1 g ha^{-1} higher than other crop establishment methods, respectively.	Shahane *et al.* (2019); Shahane *et al.* (2020)

Table 1: Continue....

Table 1: Continue....

Comparison of no-tillage with conventional plough-based tillage for their effect on soil physical properties in 36-year long-term experiment	Southeast Texas, USA	Increase in water holding capacity by 26% in no tillage over conventional tillage	Govindasamy *et al.* (2021)
Comparison of system of rice intensification, drum seeding and conventional transplanting in rice	Odisha	Increase in grain yield in SRI over conventional transplanting and drum seeding by 18% and 26%, respectively. The significantly higher values for leaf area index, dry matter accumulation, root dry weight and root volume were recorded in SRI.	Mohanty *et al.* (2014)
Comparison of flooded transplanted rice with system of rice intensification	Odisha, India	SRI had a yield advantage of 49% over flooded transplanted rice. Increase in nitrogen uptake by 26.4 kg ha^{-1} and agronomic nitrogen use efficiency was increased by 9.5 kg grain per kg nitrogen applied in SRI over flooded transplanted rice.	Thakur *et al.* (2013)
Use of bio-pesticide for management of cotton bollworm (*Helicoverpa armigera*)	South Africa	The seed cotton yield in both years of study in Bolldex® (nucleo polyhedron virus) applied plots were remained on par with the application of lambda-cyhalothrin. The increase in yield in Bolldex® ha^{-1} applied plot was 854 and 413 kg/ha in the first and second years, respectively.	Malinga and Laing, (2022)

- The number of stakeholders should be selected such that, at least parametric and /or non-parametric statistical tests can be applied to data to get valid findings and data will be suitable for further processing in developing the crop cultivation practices.
- The selection of farmers follows the statistical procedure for sampling.
- Major emphasis should be given to the crop/species which having higher shares of the total agricultural activities/ crop cultivation practices.
- Higher number of farmers should be selected for survey from the land holding group with a higher share of the total number of stakeholders and area occupied.

The secondary data from village institutions and correction in primary data by village key informants need to be considered for the more realistic data set.

Field preparation

The variables considered for collecting information from farmers regarding field preparation include: a) Types and the number of times primary, secondary and seedbed preparation are conducted; and b) Type of tillage implement used, type of energy (human, animal, petroleum fuel or electricity) used, their approximate share, influence of Govt. policy for the purchase of implement, type of tillage system followed (modern plough based, modern conservation agriculture based, tradition, *etc.*). The questionnaire for calculating rank-based coefficient (RBC) and value-based ratio (VBR) are given in Table 2.

Varietal selection

For the selection of a variety of newly introduced crops the criteria should matches with the farmer's/stake-holders criteria for choosing a crop. The economics of crop cultivation practices, resistance to insect-pest, resistance to diseases, biomass production, quality of crop produce, duration of crop/variety, a window for input applications, timing for different in-season practices, a window for different in-season practices and ranges for sowing specification are some of the criteria followed by stakeholders while introducing/ selecting new varieties. Besides that, market interventions, policy support, suitability for different secondary processing and value additions are other criteria considered by stakeholders. The problem ranking variables are given in Table 3.

Seed and sowing requirement

The seed and sowing specification is the basic of any crop cultivation practices and will decide crop performance; hence, the accurate recommendation of seed and sowing specification needs to be derived. The variables of seed and sowing include sowing time, sowing method, seed rate, spacing, sowing depth, plant population, plant geometry and seed treatments to ensure germination and emergence of vigorous seedlings. The information on the nursery, method of transplanting and age of the seedling at transplanting needs to be collected. The problems for ranking are given in Table 4.

Crop establishment methods

As the same crop can be established by different methods, information on variations in crop establishment methods and cultivation methods as well as stakeholders approaches towards them need to be generated from valid sources. The farmer's knowledge about different crop establishment methods, changes in management practices and the response of the crop to them are the major variables of study. The problems for ranking are given in Table 5.

Nutrient and water management

Nutrient and water management are important parts with a significant contribution toward the yielding ability of the crop. There are two major variables in nutrient management *viz.* organic nutrition and inorganic (Agrochemicals- fertilizers) based crop nutrition. In case of water management, it will be irrigated and rainfed agriculture. At the same time, approaches such as site-specific nutrient management, integrated plant nutrition system, integrated nutrient management and soil test-based crop response are the

Table 2: Problem ranking for calculation RBC and VBR for field preparation-related constraints.

Problem	Rank given by farmers
1. Non-availability of ideal tillage implements for field preparation	
2. Lack of labourers for field preparation	
3. Land holding constraints for tillage implement use	
4. Increased cost of energy (diesel, petrol, or electricity) for field preparation	
5. Difficulty in maintaining land configuration due to heavy rainfall	
6. Lack of crop response to preparatory tillage	
7. Community-based land preparation hence individual decision for field preparation is not possible	
8. Lack of time for land preparation due to the short turn around period	
9. Difficulty in conducting timely field preparation due to excess/ deficit rainfall or untimely rainfall	
10. Excessive growth of wild vegetation/ weeds which makes land preparation difficult and time-consuming	

Table 3: Problem ranking for calculation RBC and VBR for varietal selection-related constraints.

Problem	Rank given by farmers
1. Non-availability of quality seeds	
2. Non-availability of desired variety of seed	
3. Timeliness in seed availability	
4. The new variety available does not match the growth duration and/or not suitable for cropping systems due to longer duration	
5. The new variety is found more susceptible to biotic and abiotic stresses	
6. New varieties are nutrient-demanding and are not suitable for organic management practices followed by farmers	
7. Seedling mortality is higher in the case of new varieties	
8. Lack of capital for purchase of seeds of new rice variety	
9. Community enforcement for growing particular variety due to small land holding	

Table 4: Problem ranking for calculation RBC and VBR for seed and sowing requirement-related constraints.

Problem	Rank given by farmers
1. The optimum sowing time is difficult to achieve due to untimely seed availability, rainfall variations and other reasons	
2. Availability of labourers is a problem during transplanting	
3. The knowledge of different seed treatments under an organic production system is lacking	
4. The awareness of the significance of following the recommended package of practices is less	
5. The recommended package of practice does not work well in farmers' field	
6. Problem of germination or mortality of seedlings (or maintaining optimum plant population)	
7. Unaffordable to maintain own nursery and hence less freedom in seed and sowing changes	
8. The problems of maintaining desired plant population due to soil problems or weather abnormalities	
9. Non-availability of recommendations for traditional varieties (Black rice/ scented rice)	
10. Weeds may create problems in seedling establishment	

major improved nutrient recommendation for crop nutrition. For water management, the application criteria, scheduling of irrigation, rainfall water conservation (*in-situ* and *ex-situ*) and its utilization are the other variables. The information on schedule of nutrient application, criteria for selection of above-mentioned variables, farmers' perception about the use of bio-fertilizers, farmers perception about the use of biodynamic formulation and soil testing are the other variables for collecting the information from the stakeholders. For water management, source of irrigation, land configurations for water management, drainage of excess water and matching with the government policies for water/irrigation management are the major variables for which information needs to be collected. The problem ranking for both nutrient and water management is given in Tables 6 and 7.

Weed management

The weeds, insect-pest and diseases are the major biotic stresses causing accountable damage to crop produce. At present, chemical methods (herbicide/ weedicide) are considered as most efficient methods for weed management; while the land holding, cropping system (intercropping, mixed cropping), knowledge about herbicide and availability of herbicide in time are the major variables for which information need to be generated. This information needs to be generated on-station and gathering

Table 5: Problem ranking for calculation RBC and VBR for crop establishment methods related constraints.

Problem	Rank given by farmers
1. Availability of labourers will affect the selection of crop establishment methods	
2. Availability of implements will affect the selection of crop establishment methods	
3. Prevailing weather conditions will affect the selection of crop establishment methods	
4. Soil inherent properties will affect the selection of crop establishment methods	
5. Availability of organic manure affects the selection of crop establishment methods	
6. The next season's crop affect the selection of crop establishment methods	
7. Small land holding and shape of land affect the selection of crop establishment methods	
8. The slope of land affects the selection of crop establishment methods	

Table 6: Problem ranking for calculation RBC and VBR for nutrient management-related constraints.

Problem	Rank given by farmers
1. Lack of knowledge about the amount of nutrients required by crops (quantity and number of nutrients/crop response to different nutrient applications)	
2. Lack of capital for the purchase of organic manure	
3. Non-performance of bio-fertilizers or no yield improvement due to bio-fertilizers	
4. Lack of knowledge about in-season nutrient management	
5. Non-availability of manures in time	
6. Low response of selected variety or local variety to externally applied nutrients	
7. Farmer following subsistence agriculture and hence no manure addition	
8. Lack of soil testing facilities and hence the calculation of nutrient requirement for crops is difficult	
9. Non-availability of organic manure treatment plants in nearby area	
10. Lack of knowledge providing the source for the enrichment of compost	
11. Fertilizer management will be difficult due to rainfall	

Table 7: Problem ranking for calculation RBC and VBR for water management-related constraints.

Problem	Rank given by farmers
1. Excess rainfall makes water management difficult	
2. The land configuration prepared is not stable due to excess rainfall	
3. Lack of modern irrigation facilities such as pumping devices, irrigation canals, *etc*.	
4. Lack of water storage facilities	
5. Lack of awareness about the management of water at different growth stages	
6. No response of crops to water management practices	
7. No interest in spending money on water management due to sufficiency and adequate water availability throughout the season	

information from the farmer for this will not give any inputs for modulation or development of the package of practices. The other variables for which information needs to be collected include methods followed, economics of methods followed, constraints in selecting the best methods, precautionary measures taken and cultural practices followed. The problem ranking for both nutrient and water management is given in Table 8.

Table 8: Problem ranking for calculation RBC and VBR for weed management-related constraints.

Problem	Rank given by farmers
1. Lack of awareness about the significance of weed management	
2. Low response of crop to weed management in terms of yield improvement	
3. There is not much weed problem in selected crops	
4. Heavy rainfall leads to lesser weed problem in selected crops	
5. Heavy rainfall makes weed management difficult	
6. Lack of improved tools and implements for weed management	
7. Lack of capital for weed management	
8. Weed will also serve as the fodder and hence allow to grow	
9. Labourers from the family will be sufficient for weed management; hence there is no need for any external weed management practice	

Table 9: Problem ranking for calculation RBC and VBR for yield-related constraints.

Problem	Rank given by farmers
A) The yield level achieved by the farmer is lower than the yield accepted as given by the ICAR (Other institutions). If so, then because of:	
1. Use of a local variety	
2. Due to heavy rainfall	
3. Due to low fertility addition	
4. Due to less than optimum plant population	
5. Due to heavy rainfall at the time of harvesting leading to quality deterioration	
6. Due to the weed population	
7. Due to unavailability of resources on time	
8. Due to unavailability of enriched manure (vermi-compost, *etc*.) for in-season nutrient management	
9. Due to insect-pest and disease incidence (for the last three years)	
10. Due to low soil fertility	
B) The yield level achieved by farmers is higher than the yield accepted as given by the ICAR (other institutions). If so, then because of:	
1. Due to high soil fertility	
2. Due to better management	
3. Due to excess fertility addition	
4. Due to better varietal selection	
5. Due to local varieties which are resistant to the biotic and abiotic stresses	
6. Better quality due to local-scented rice varieties	

Table 10: Problem ranking for calculation RBC and VBR for economics-related constraints.

Problem	Rank given by farmers
1. The net returns are less than the cost incurred	
2. High cost involved in crop management	
3. Labourer charges increase due to which the cost of cultivation increases	
4. The price at which farm produce is sold is lesser than MSP	
5. No additional returns were obtained from by-produce (straw) of crop	
6. No additional price as the produce is of an organic nature	
7. Marketing facilities for selling of organic produce are lacking	
8. Lack of awareness about the premium prices to organic produce	
9. The loan facilities are not available on time	
10. Less access to medium-term loan facilities to do development activities on farm	

Yield and economics

The impact of cultivation practices followed on crop performance is judged by realized yield in the field. The quality of produce, days to maturity, difficulties in threshing, difficulties in harvesting, suitability to post-harvest processing and surplus available for sale after meeting family requirements are the points of investigation to get an idea about the crop produce status. These variables are also extended to the economics of crop cultivation. The problems in achieving the optimum yield level and economic problems are given in Tables 9 and 10 for the calculation of RBC and VBR.

CONCLUSION

The point of consideration for questionnaire preparation given herewith will guide in the collection of complete information. This will be helpful in determination of modulation needed in present cultivation practices and also development of the package of practices for newly introduced crops/ species of crop or variety. Questionnaire preparation for information collection is still a prominent way of gathering information in the NEH region considering the remoteness and large diversity involved in crop cultivation practices. This will give insight into the practices followed and a comparison of them with the recommended practices suggested for a given area. The traditional knowledge about the production system of crops followed by local communities and modifications made by them in recommended practices will give more information which can be useful for developing or changing the production practices.

Conflict of interest

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