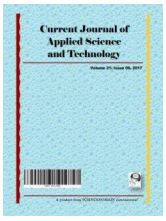

Current Journal of Applied Science and Technology

29(5): 1-8, 2018; Article no.CJAST.44880
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Discerning of Biologically Proficient Rice and Maize Based Cropping Sequences in Central Plain Zone of Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/44880
Editor(s):
(1) Dr. Teresa De Pilli, Assistant Professor, Department of Science of Agriculture of Food of Environment (SAFE), University of Foggia, Via Napoli, Italy.
Reviewers:
(1) Julian Gonzalez Trinidad, Autonomous University of Zacatecas, Mexico.
(2) R. K. Mathukia, Junagadh Agricultural University, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/26753

Original Research Article

Received 07 August 2018
Accepted 20 October 2018
Published 22 October 2018

ABSTRACT

Aim: Comparative evaluation of various rice and maize based cropping sequences and assessment of their productivity.
Study Design: Descriptive statistics was used and each treatment was replicated quadruple times using randomized block design.
Place and Duration of Study: Department of Agronomy, CSA University of Agriculture and Technology, Kanpur, Uttar Pradesh, India from 2010-2017.
Methodology: We have undertaken traditional cropping systems along with some new proposed cropping sequences in central plain zone of Uttar Pradesh to find out the biologically efficient cropping systems in terms of rice equivalent yield. We implemented randomized block design in the field level to layout the different crops according to the various seasons in terms of space and time. Various inputs like water, fertilisers, chemicals etc. applied accordingly as per their recommendation. Different types of cultural practices are implemented to fulfill the crop needs. Timely samples are drawn from all the crops to analyze the characteristics of their biological yield and production efficiency.

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Result: Among four rice based cropping sequences, hyb. rice –wheat-green gram (G+R) and six maize based cropping sequences, maize+blackgram-potato-onion cropping sequences were recorded the highest rice equivalent yield of 219.04 Kg/ha and 320.43 kg/ha respectively. In terms of production efficiency (kg/ha/day) same trend was followed.
Conclusion: On the basis of overall productivity, biological yield, production efficiency and land use efficiency it may infer that hyb. rice-wheat-green gram (G+R) and maize+blackgram-potato-onion crop sequences were treated as best biologically efficient cropping sequences among rice based and maize based cropping sequences, respectively.

Keywords: Cropping sequence; biological yield; production efficiency; land use efficiency.

1. INTRODUCTION

Planning and adoption of suitable cropping is essential for ensuring the most rational use of land and increasing the productivity/unit area/unit time so that farmers can get a maximum net return from the cropping system. Cropping system signifies the sequence of crops grown over a specific piece of cultivated land and to increase the benefits from the available resources. Therefore, the basic approach in an efficient cropping system is to increase production and economic returns. Rice –wheat cropping system (RWCS) is the world's largest agricultural production system occupying around 12.3 m ha in India and around 85 percent of this area falls in Indo-Gangetic plains (IGP) [1]. The farmers realise much of their food security from this cropping system. This cropping system is predominant in irrigated production system of North and Central India which is mainly concentrated in Indo - Gangetic plains. It is also practiced under rain fed ecosystem in pockets, where rainfall is good and soils conserve adequate residual soil moisture to grow wheat succession to rice in a sequence. This system has sustained over years and brings together conflicting and complementary practices. Because of high productivity, stability and less risk, the wide adoption of this system will also play a major role in future planning to sustain self sufficiency of food grains in the years to come. This system requires high input resources for higher productivity resulted higher cost per unit area and time. Following continuously the same system has adverse effect on soil health, ultimately decline in factor productivity of the system [2]. But now the productivity of both the crops have stagnated [3] and factor productivity is declining year after year.

Maize-wheat cropping system is the third most important cropping system after rice-wheat and rice-rice. This is being followed in upland irrigated ecology of Indo Gangetic Plains of India. In this system wheat is normally irrigated condition. Among different maize based cropping systems, maize-wheat ranked first followed by maize-mustard. Maize has compatibility with several crops of different growth habit that led to development of various intercropping systems. Studies carried out under various soil and climatic conditions under All India Coordinated Research Project on cropping systems revealed that compared to existing cropping system like rice-wheat and rice-rice, maize based cropping systems are better user of available resources (agridaklali.iasi.res.in).

Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertiliser and pesticide loads, ensuring environmental safety and creating employment opportunity [4]. Crop diversification has been recognised as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement [5].

To strengthen the food and economic security, it is imperative to intensify and diversify the existing rice-wheat and maize-wheat systems with some other crops of greater economic worth. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops as it offers a wider choice in crop production in a given area to expand production related activities and also to lessen risk. However, in areas of shrinking resource base of land, water and energy, diversification of rice-based system to increase productivity per unit resource is very pertinent. As resource- use efficiency is an

important aspect for considering the suitability of a cropping system. So, diversification has been envisaged as a new strategy for enhancing and stabilising productivity, making Indian agriculture competitive and increasing net farm income and economic security toward achieving the sustainable agricultural development. The inclusion of crops like oil seeds, pulse and vegetable will improve the economic condition of the farmers owing to higher price and higher volume of their main and by-products. The legumes will also show a favourable effect on soil health [6]. The economic value of these crops is comparatively quite low then other crop (pulses, oilseeds and vegetable crops). Though the market value of mustard, potato, garlic and onion are considerable good with the less cost of production, their productivity is quite good than other crops. Hence, there is need to diversify the cropping systems that are prevailed in central plain zone of Uttar Pradesh aimed to more profit, increase exports and competitiveness in both domestic and international markets, improving soil health protecting environment and facilitating better cropping system with higher productivity per unit area.

Cropping systems in central plain zone region aims to make agriculture achieving nutritional scarcity, more employment and income generating, ecofriendly, poverty alleviation and comparative advantage in new trade regime. Keeping above facts in view, the present investigation "**Discerning of biologically proficient rice and maize based cropping sequences in central plain zone of Uttar Pradesh**" under All India Coordinated Research Project on Cropping Systems was conducted.

2. MATERIALS AND METHODS

The field experiment was conducted during 2010-17 at Student's Instructional Farm, C.S. Azad university of Agriculture and Technology, Kanpur to identify the biologically proficient cropping systems. The soil was neutral to slightly alkaline of alluvial type having pH 7.8, 0.55 % organic carbon, available nitrogen (223 Kg/ha), low in available phosphorus (14 Kg/ha) and medium in available potash (216 Kg/ha). A total of ten cereal based crop (four rice based and six maize based) rice-wheat, hyb. rice-wheat, hyb. rice-wheat-green gram (G+R), scented rice-wheat-okra, maize-wheat, maize-mustard-onion, maize-mustard-green gram (G+R), maize+green gram-potato-wheat, maize+black gram-potato-onion and maize-garlic-green gram (G+R) sequences were tested. The system productivity and production efficiency of each year have been computed to evaluate the efficiency of different crop sequences. Land use efficiency was worked out by taking a total duration of crop in individual crop rotation divided by 365 days and production efficiency (kg/ha/day) was obtained by dividing the total productivity of cropping system in terms of rice equivalent yield by total duration of the system [7].

3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

3.1 Biological Yield and System Productivity

Total biomass and grain yield production per unit area supposed to be resultant effect of plant stand as well as growth and yield attributes of plant. In the present field study, biological and grain yield of rice were the highest when it was grown in hyb. rice-wheat-green gram (G+R) crop sequence as compared to the rice-wheat, hyb.rice-wheat and scented rice-wheat-okra mainly due to the potentiality of hybrid rice followed by positive effect of greengram grown during zaid season (Table 1). Mahapatra et al. [8] also recorded higher biological and grain yield of hyb. rice as compared to general rice.

In the present study, the biological and grain yield of maize crop was highest when it was grown in maize-mustard-green gram crop sequence (Table 1) because of the beneficial effect of green gram grown in zaid season. In the present study, the biological and grain yield of wheat were also seemed to be associated with plant stand, growth and yield attributes of wheat. Biological and grain yield of wheat were the highest in maize-wheat crop sequence mainly due to plant population per unit area coupled with growth and yield attributes of maize which were the highest in maize-wheat crop sequence (Table 1). The biological and grain yield of wheat was lowest when it was grown in maize+black gram-potato-wheat mainly due to the fact that wheat crop was sown during January there by reducing the growth and yield attributes of the wheat. Singh and Dhaliwal [9] also recorded lower biological and grain yield of wheat due to delayed sowing.

Table 1. Biological yield, grain yield, straw yield and harvest index of crops in each crop sequence during 2016-17

Crop rotations	Kharif				Rabi				Zaid
	Biological yield (Kg/ha)	Grain (Kg/ha)	Straw (Kg/ha)	Harvest index (%)	Biological yield (Kg/ha)	Grain (Kg/ha)	Straw (Kg/ha)	Harvest index (%)	Grain (Kg/ha)
T_1: rice-wheat	10895.23	4952.38	5942.85	45.45	9769.52	4380.95	5388.57	44.84	-
T_2: hyb. rice-wheat	17458.00	8120.00	9338.00	46.51	10458.70	4690.00	5768.70	44.84	-
T_3: hyb. rice-wheat -green gram(G+R)	18102.96	8381.00	9721.96	46.29	10582.06	4810.00	5772.06	45.45	835.00
T_4: maize-wheat	12026.70	2905.00	9121.70	24.64	10928.56	4857.14	6071.42	44.44	-
T_5: maize-mustard-onion	12183.50	2950.00	9233.50	24.43	7706.16	1785.71	5920.45	23.17	12928.75
T_6: maize-mustard-green gram (G+R)	13082.61	3070.86	10011.75	23.47	8279.36	1922.22	6357.14	23.21	920.67
T_7: maize+green gram-potato-wheat	11879.75 (M) 1794.75 (GG)	3000.00(M) 381.00 (GG)	8879.75 (M) 1413.75 (GG)	24.52 (M) 21.22 (GG)	- 7062.25	20880.75 3435.50	- 3626.75	- 48.64	-
T_8: maize+black gram-potato-onion	12801.50 (M) 1898.50 (BG)	3047.75 (M) 452.00 (BG)	9753.75 (M) 1446.50 (BG)	23.80 (M) 23.80 (BG)	-	24238.00	-	-	13950.00
T_9: maize-garlic-green gram (G+R)	13160.46	3118.75	10041.71	23.69	6714.25	6714.25	-	-	976.00
T_{10}: rice-wheat-okra	13304.75	4786.00	8518.75	45.66	9280.75	4357.25	4923.50	46.94	3262.00

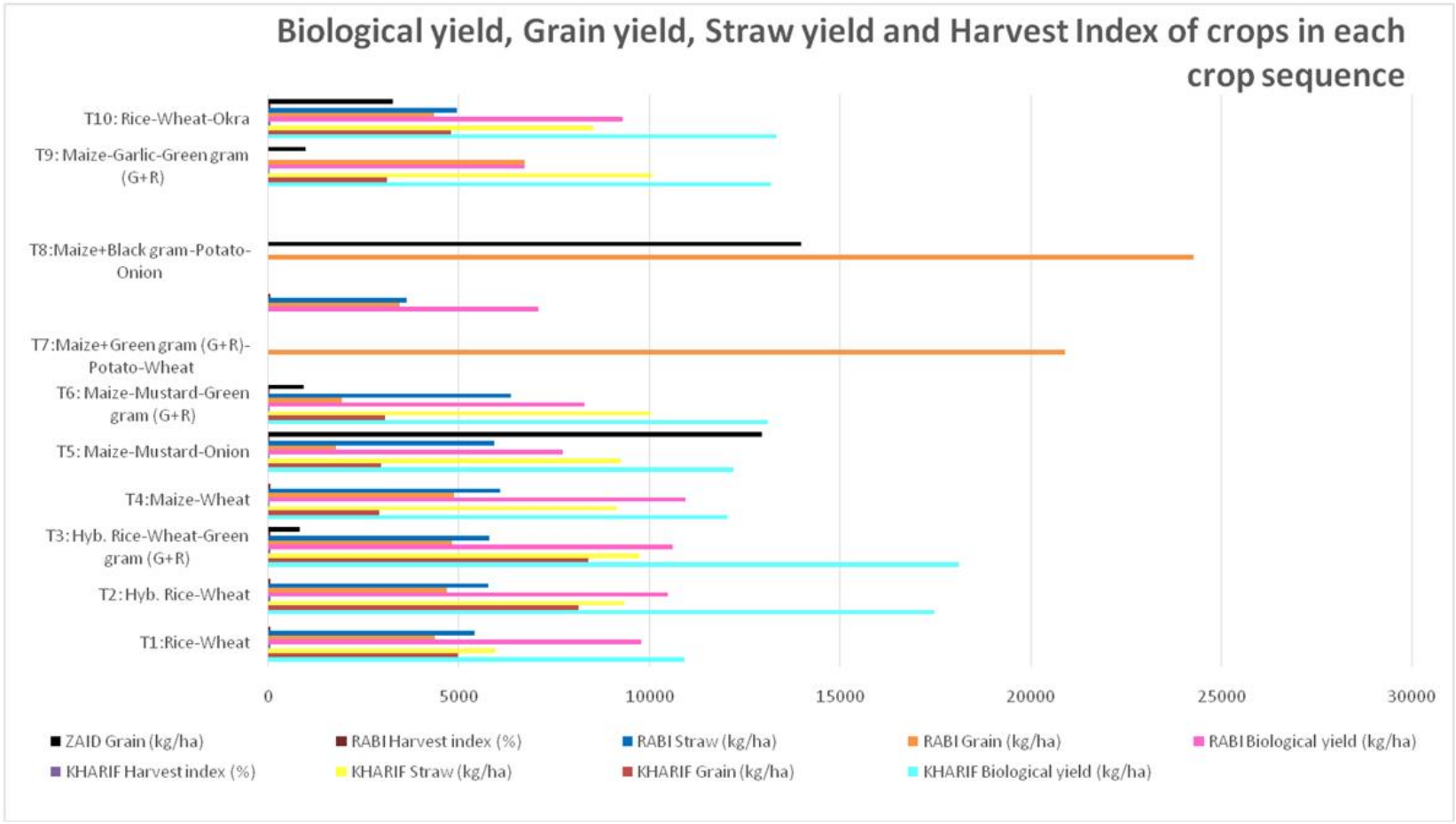
Biological yield, Grain yield, Straw yield and Harvest Index of crops in each crop sequence
T10: Rice-Wheat-Okra
T9: Maize-Garlic-Green gram (G+R)
T8:Maize+Black gram-Potato-Onion
T7:Maize+Green gram (G+R)-Potato-Wheat
T6: Maize-Mustard-Green gram (G+R)
T5: Maize-Mustard-Onion
T4:Maize-Wheat
T3: Hyb. Rice-Wheat-Green gram (G+R)
T2: Hyb. Rice-Wheat
T1:Rice-Wheat
0
5000
10000
15000
20000
25000
30000
ZAID Grain (kg/ha)
RABI Harvest index (%)
RABI Straw (kg/ha)
RABI Grain (kg/ha)
RABI Biological yield (kg/ha)
KHARIF Harvest index (%)
KHARIF Straw (kg/ha)
KHARIF Grain (kg/ha)
KHARIF Biological yield (kg/ha)

Fig. 1.

The highest system productivity obtained through maize+black gram-potato-onion crop sequence followed by maize+green gram-potato-wheat over all crop sequences evaluated. So that it concludes maize+black gram-potato-onion was well efficient cropping system (Table 1).

3.2 Land Use Efficiency and Production Efficiency

Cropping system analysis not only illustrates the current land use but also it reflects how the land pattern changed over the time [8]. In the present study, higher land use efficiency of 92.32% was found in scented rice-wheat-okra crop sequence due to longer duration of crop sequence (337) followed by hyb. rice-wheat-green gram (G+R) (90.13%), maize-garlic-green gram (G+R) (85.20%). Land use efficiency (61.64%) was recorded lowest in maize-wheat crop sequence followed by maize+green gram-potato-wheat (67.39%). Similar results were drawn by Gangwar and Ram [10].

Data pertaining to production efficiency of various crop sequences are given in Table 2. Growing period of a crop depends on the phenology of crop and its varieties. Besides the genetic ability of crop/variety, the existing agro climatic conditions of the locality and managerial practices followed for its cultivation also have their much concern with the growth, development and yield of crops.

The combined yields in terms of rice equivalent yield (REY) of all crop components under a particular crop-sequence were significantly greater under all newly tested crop-sequences over both existing most common crop sequences i. e. rice-wheat and maize-wheat. The yield of different crop – components grown under various diversified intensive crop seasons were higher than those of obtained from the crops grown under both existing crop sequences, which contributed to higher system productivity or total productivity of entire crop-sequences as a whole. It is remarkable here that no any summer crop was grown under both existing cropping systems as per common practices prevalent among the farmers of the region. Thus, inclusion of summer crops in all diversified crop sequences mainly contributed to enhance the system productivity with the supplementation of yield by summer crops. Though additional time and agro-inputs including irrigation water was needed for these diversified crop sequences, the increase in yield was more efficient rather than increased values of agro-inputs. Among different crop-sequences tested, maize+black gram-potato-onion markedly registered the highest production efficiency (121.83 kg/ha/day). The next best crop sequence was maize-garlic- green gram (G+R) (93.61) closely followed by maize-mustard-onion (88.20 kg/ha/day) (Table 2). Same trend followed in terms of rice equivalent yield of different cropping sequences tested.

Remaining diversified intensive crop-sequences recorded production efficiency ranging from 52.38 to 82.03 kg/ha/day. Potato being a high yielding crop during rabi season resulted into handsome production efficiency of 121..83 kg/ha/day under maize+black gram-potato-onion system, although maize-mustard-green gram (G+R) and rice-wheat were low yielders over other remaining crop sequences. Similar high values of production efficiencies with the inclusion of high yielding crops under existing cropping systems have been also reported by several other workers from different agro climatic conditions. Same results were recorded by Yadav et al., Yadav et al., Jain et al, [11,12,13].

Table 2. Rice equivalent yield (q/ha), duration of the crop sequence, land use efficiency and production efficiency of each crop sequence during 2016-17

Crop rotations	Rice equivalent yield (q/ha)	Duration of crop sequence (days)	Land use efficiency (%)	Production efficiency (Kg/ha/day)
T_1: rice-wheat	140.76	267	73.15	52.72
T_2: hyb. rice-wheat	187.38	267	73.15	70.18
T_3: hyb. rice-wheat-green gram (G+R)	219.04	329	90.13	66.57
T_4:maize-wheat	136.82	225	61.64	60.80
T_5: maize-mustard-onion	250.49	284	77.80	88.20
T_6: maize-mustard-green gram (G+R)	138.81	262	72.60	52.68
T_7: maize+green gram-potato-wheat	195.35	246	67.39	79.41
T_8: maize+black gram-potato-onion	320.43	263	72.05	121.83
T_9: maize-garlic-green gram (G+R)	291.14	311	85.20	93.61
T_{10}: rice-wheat-okra	190.78	337	92.32	56.61
CD (P=0.05)	6.47	-	-	2.42

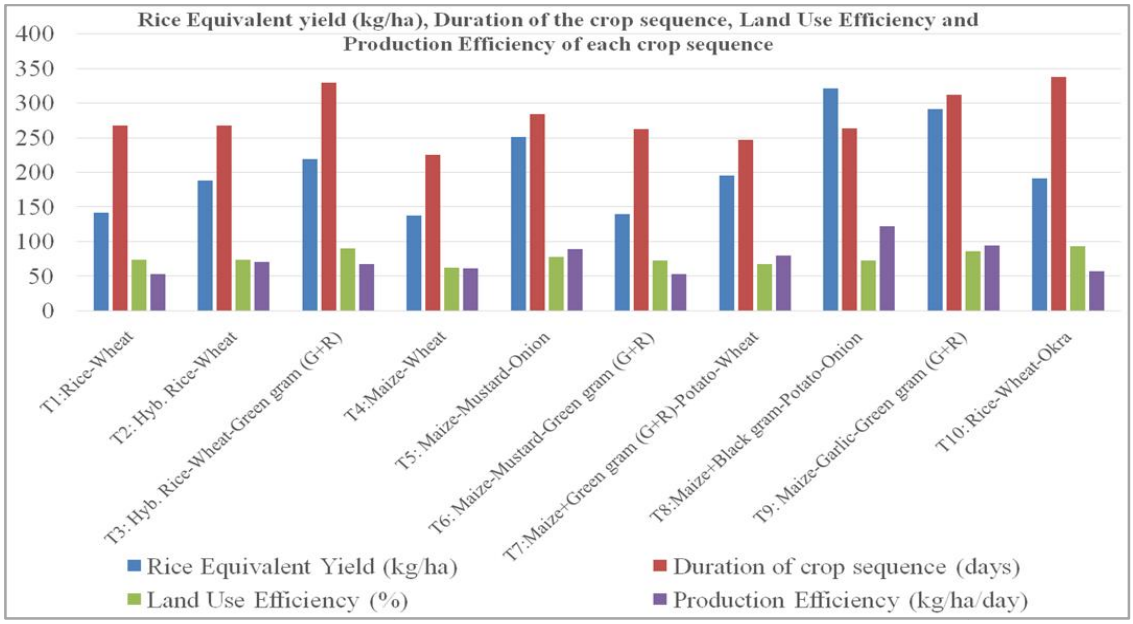

Fig. 2.

Market prices of different crops: Rice grain- Rs.1400/q, rice straw- Rs.400/q, wheat grain- Rs.1635/q, wheat straw- Rs.400/q, black gram grain- Rs.5000/q, black gram straw- Rs.100/q, green gram grain- Rs.4450/q, green gram straw- Rs.100/q, maize grain- Rs.1350/q, maize straw- Rs.100/q, mustard seed- Rs.3400/q, mustard straw- Rs.100/q, garlic- Rs.4200/q, onion- Rs.1500/q, potato- Rs.500/q and okra-2000/q.

4. CONCLUSION

Thus it may be concluded that traditional rice-wheat system could not able to improve biological efficiency per unit area and time. Replacing traditional rice –wheat system with maize based intensive and biological efficient crop sequences could enhance the total productivity and production efficiency. On the basis of overall productivity biological efficiency and production efficiency, it may infer that Maize+black gram-potato-onion cropping sequence is treated as best biologically efficient system among maize based and Hyb.Rice-wheat-green gram (G+R) among rice based cropping sequences.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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