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Effect of solid and liquid organic supplements on yield, physical characteristics and quality of rice

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Abstract
Field experiments were conducted during *Rabi* seasons of 2019 and 2020 (*September to January*). Medium duration rice cv. white ponni (improved) was used as a test variety at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam, Thoothukudi District, India. The objective of the research is to study the influence of solid and liquid organic manures (Enriched FYM compost, Enriched poultry manure compost, Enriched FYM compost + 3% Jeevamrutham foliar spray at 30and 45 days after transplanting, Enriched FYM compost + 3% Beejamrutham foliar spray at 30&45 DAT, Enriched FYM compost + 3% Panchagavya foliar spray at 30and 45 days after transplanting, Enriched poultry manure compost + 3% Jeevamrutham days after transplanting at 30 and 45 days after transplanting, Enriched poultry manure compost + 3% Beejamrutham foliar spray at 30 and 45 days after transplanting and Enriched poultry manure compost + 3% Panchagavya foliar spray at 30 and 45 days after transplanting and recommended NPK fertilizers on yield and quality of rice. Based on field experiments, it was found that the application of enriched poultry manure compost + 3% Panchagavya foliar spray at 30 and 45 days after transplanting recorded higher yield attributes and grain yield of rice (4597 kg ha^{-1} in 2019 and 4953 kg ha^{-1} in 2020). The application of enriched poultry manure compost + 3% Panchagavya foliar spray at 30 and 45 days after transplanting recorded higher physical characteristics and cooking qualities of rice.

Keywords: Organic supplements, transplanted rice, foliar spray, yield and quality

Introduction
One in three people on the planet rely on rice (*Oryza sativa* L.) for half of their daily sustenance, making it the most significant and widely grown food crop. Rice and its derivatives provide 60-70% of the energy consumed by almost two billion people in Asia alone. Inorganic fertilizers are used more often in crop production, which degrades soil health, increases health risks, and creates food insecurity. Energy crises, increased fertilizer costs, agri-production system sustainability, and ecological stability are some of the major challenges that have rekindled interest among farmers and researchers in non-chemical plant nutrition sources such as composts, farmyard manure, green manure, and biofertilizers. People's interest in organic farming grew as they became more conscious of crop quality and soil health (Sharma, 2008) [13]. As a result, organic farming-which mostly uses resources found on the farm and usually avoids the use of artificial fertilizers-is becoming more and more popular. Higher concentrations of macro and micronutrients, essential amino acids, growth-promoting substances like IAA, GA, and beneficial microbes in liquid and solid manures may significantly aid in boosting soil fertility and microbial populations, which in turn may improve crop growth, yield, and quality (Sreenivasa, 2009) [16]. To maintain soil fertility and generate the highest crop production with the least amount of input, a balanced application of nutrients from organic sources such as farmyard manure, vermicompost, green manuring, neem cake, and biofertilizers is necessary (Dahiphale, 2003) [2]. For the sequence crops, the organic manures provide a sufficient residual effect (Singh, 1996) [15].
Fewer studies have examined the effects of liquid organic manures, such as panchagavya, jeevamrutham, and beejamrutham, either by themselves or in combination with solid organic manures, on finger millet.

By increasing the activity of microflora and fauna, organic liquid formulations such as jeevamrutham and panchakavya aid in the rapid development of soil fertility (Yogananda, 2019) [19]. These are essential for fostering plant development and immunity since they combine the qualities of fertilizer and biopesticide. Maintaining soil fertility and the financial stability of the farming community can be greatly aided by any combination that lessens reliance on chemical fertilizers and other resources.

In view of the above facts, field experimenton "Influence of solid and liquidorganic supplements on yield and quality of rice" was conducted with the following objectives.

1. To study the influence of different sources organic supplements on growth and yield of rice
2. To know the effect of organic supplements on quality of rice grain

Materials and Methods

At the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam, Thoothukudi District, which is situated in the Southern Agro-climatic Zone of Tamil Nadu at 8° 46' North latitude and 77° 42' East longitude, and at an elevation of 40 meters above mean sea level, field experiments were carried out during the rabi seasons of 2019 and 2020. With a slightly alkaline pH of 8.1 and a clay loam texture, the experimental field's soil had low soluble salts (EC=0.45 $dS \cdot m^{-1}$), a medium organic carbon content (0.52%), low available nitrogen (262 $kgha^{-1}$), medium available phosphorus (18.2 $kgha^{-1}$), and high available potassium (576 $kgha^{-1}$).

The experiment was laid out in randomized block design with ten treatments replicated thrice using two different organic manures (Enriched FYM and Enriched poultry manure) each in combination with three different liquid organic supplements (Jeevamrutham, Beejamrutham and Panchagavya as foliar sprays) as per the treatment schedule *viz.*, enriched FYM compost, enriched poultry manure compost, enriched FYM compost + 3% jeevamrutham FS at 30& 45 DAT, enriched FYM compost + 3% beejamrutham FS at 30 & 45 DAT, enriched FYM compost + 3% panchagavya FS at 30 & 45 DAT, enriched poultry manure compost + 3% jeevamrutham FS at 30&45 DAT, enriched poultry manure compost + 3% beejamrutham FS at 30 & 45 DAT and enriched poultry manure compost + 3% Panchagavya FS at 30 & 45 DAT and recommended NPK fertilizersand absolute control (without organic and inorganic).Two weeks before to rice transplanting, the necessary amounts of organic manures were added to the soil based on the equal N foundation. Applying 150:50:50 $kg \cdot ha^{-1}$ of N, P, and K in the form of urea (46% N), single super phosphate (16% P2O5), and muriate of potash (60% K2O) to the rice crop was the recommended NPK fertilizer treatment. At the basal, active tillering, panicle initiation, and blooming periods, the N was applied in four equal splits. Prior to seeding, the full dosage of P and K was administered topically. Improved white ponni was the rice variety that consumers preferred. In the main field, transplanting was carried out at two seedlings hill-1 with a 20 × 10 cm spacing. Other management practices were adopted as per recommendation of the crops.

Enriched Organic Manure Preparation

A heap-like structure was created by thoroughly mixing 1000 kg of decomposed and powdered farmyard manure on a dry weight basis with 10 kg of rock phosphate and 10 kg of each of the biofertilizers-Azospirillum, Azotobacter, and Phosphobacteria-to create the enriched farmyard manure compost. The pile was left in the shade with 60% moisture for 60 days to compost. A heap-like structure was created by completely mixing 1000 kg of poultry manure on a dry weight basis with 20 kg of rock phosphate and 10 kilogram of each of the biofertilizers-Azospirillum, Azotobacter, and Phosphobacteria-to create an enriched poultry dung compost. The pile was left in the shade with 60% moisture for 60 days to compost (Sims, 1992) [14]. The manurial value of organic manures was analysed and quantity required for the experiment was worked out based on equal N basis.

Biometric and Yield Observations

Each plot had five randomly chosen and tagged plants. At various phases of crop development, biometric observations were recorded using these plants. Each net plot's harvested food was threshed, sun-dried, and winnowed separately. The grain yield, measured at 14% moisture content, was then expressed in kilograms per hectare. After sufficient sun drying, the rice straw yield from the net plot area was measured and expressed in kilograms per hectare.

Rice grain Quality Analysis

The rough rice (paddy) was cleaned, dried to 12 to 14 percent moisture and dehulled with a McGill laboratory sheller. After hulling, the brown rice was milled and polished in a Kett polisher for a standard time to find out the milling percentage and head rice recovery.

$$\text{Milling recovery (\%)} = \frac{\text{Total milled rice}}{\text{Total milled rice}} \text{x } 100$$

$$\text{Head rice recovery (\%)} = \frac{\text{Total head rice}}{\text{Total rough rice}} \text{x } 100$$

Broken rice percentage is defined as the percentage of broken rice to the weight of total quantity of rice obtained by shelling.

Broken rice (%) = [W2/(W1+W2)] × 100

Where, W1: Weight of whole rice in the sample (g); W2: Weight of broken rice in the sample (g).

Ten uniformly sized rice grains were arranged lengthwise on a graph paper to determine the grain length. The mean length was then measured and reported in millimeters. Ten uniformly sized rice grains were arranged breadthwise on a graph paper to determine the breadth of the grains. The mean breadth was then measured and reported in millimeters. The ratio of the cooked to the uncooked volume is known as the volume expansion ratio. A boiling test tube was filled with five grams of rice, and the level was noted. Water was added to cook it, and the rice's level was noted as well. The water displacement method was used to measure the volume.

The weight ratio of cooked to uncooked rice is known as the water absorption ratio (Khan and Ali 1985) [8]. After soaking for 10 to 30 minutes, ten regular milled grains are dropped immediately into boiling water, or they can be placed in a wire cage or basket until the ideal cooking time is reached. The length-to-breadth ratio (LBAC) was calculated by measuring the length and width of the cooked rice.

$$\text{LBAC} = \frac{\text{Kernel length after cooking}}{\text{Kernel breadth after cooking}}$$

Plain cooked rice was evaluated by a trained panel of judges for

their sensory attributes consisting of colour, texture, taste and overall acceptability using a score card with nine point Hedonic scale (Watts 1989) [17].

Statistical Analysis

The data on various characters studied during the course of investigation were statistically analysed by Gomez and Gomez 1984) [5]. Wherever treatment differences were significant ("F" test), critical differences were worked out at five percent probability level. Treatment differences that were not significant were denoted as "NS".

Results and Discussion

Influence of Organic supplements on Rice

During both the years of field trial, yield attributing characters *viz*., productive tillers m^{-2}, number of grains $panicle^{-1}$ and grain and straw yield of rice were influenced significantly by the application of organic supplements and recommended NPK through fertilizer (Table 1).

Table 1: Influence of solid and liquid organic supplements on yield characters and yield of rice

Treatments	Productive tillers ($No.m^{-2}$)		No. of grains $panicle^{-1}$		Grain yield ($kg\ ha^{-1}$)		Straw yield ($kg\ ha^{-1}$)	
	2019	2020	2019	2020	2019	2020	2019	2020
Absolute control	198	213	127	143	2268	2635	3216	3516
Recommended NPK fertilizers	213	257	149	184	3199	3265	4499	4823
Enriched FYM compost	214	228	160	166	2558	2611	3661	3958
Enriched poultry manure compost	229	243	171	175	2879	2937	4080	4393
Enriched FYM compost + 3% jeevamrutham FS at 30 & 45 DAT	265	272	194	197	3583	3643	5107	5388
Enriched FYM compost + 3% beejamrutham FS at 30 & 45 DAT	258	269	192	193	3520	3594	4918	5254
Enriched FYM compost + 3% panchagavya FS at 30 & 45 DAT	280	287	204	206	3904	3969	5525	5827
Enriched poultry manure compost + 3% jeevamrutham FS at 30 & 45 DAT	297	305	215	219	4274	4386	6036	6351
Enriched poultry manure compost + 3% beejamrutham FS at 30 & 45 DAT	294	301	214	216	4225	4297	5945	6258
Enriched poultry manure compost + 3% Panchagavya FS at 30 & 45 DAT	312	319	226	229	4597	4715	6458	6785
SE.d	4.9	6.1	3.9	3.4	157.9	160.3	207.5	213.2
CD (P=0.05)	11.5	12.7	8.4	7.5	318.6	324.2	416.5	428.3

FYM; Farm yard manure, DAT; Days After Transplanting, FS; Foliar spray

The number of productive tillers m-2 and the number of grains panicle-1 were increased by applying enriched poultry manure compost + 3% Panchagavya FS at 30 and 45 DAT. This was followed by applying enriched poultry manure in conjunction with 3% jeevamrutham spray at 30 and 45 DAT, which maintained parity with that caused by applying enriched poultry manure + 3% beejamrutham spray at 30 and 45 DAT. This was found to be superior to applying 100% FYM + 3% panchagavya spray at 30 and 45 DAT. NPK fertilizer was suggested after these. Compared to the absolute control during Rabi 2019 and 2020, the enhanced poultry manure compost plus 3% panchagavya spray at 30 and 45 DAT increased the number of grains panicle-1 (77.9% and 60.0%) and productive tillers (57.5% and 49.7%). This could be because, in comparison to other organic manures, the enriched poultry manure compost has a higher concentration of macro and micronutrients as well as a higher continuous nutrient release. Additionally, the fertilizer value was almost three times higher than FYM due to the presence of both fecal and urine discharge in the poultry manure (Devegowda 1997) [3].

Better tiller production and more grains in rice are the results of the enriched organics' improved and ongoing delivery of nutrients (Mohandas 2018) [9]. According to similar findings, a higher macro and micronutrient content in poultry manure, which permits a continuous, slow, and steady release of nutrients, in conjunction with panchagavya foliar spray, enhanced nutrient uptake and may have contributed to improved yield attributes (Gawade, 2013; Ananda, 2017) [4, 1].

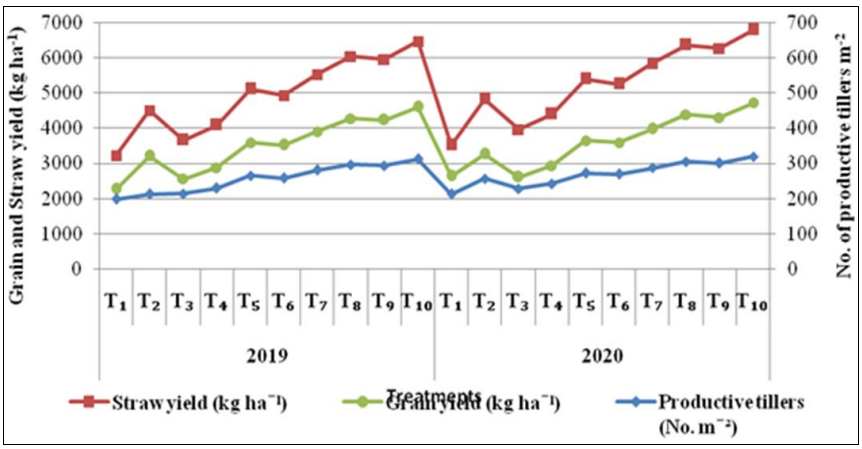

Fig 1: Influence of organic supplements on yield characters and yield of rice

The grain and straw yield was very much influenced by different organic supplement treatment combinations.The application of enriched poultry manure compost + 3% panchagavya spray at 30 & 45 DAT recorded higher grain yield (4597 $kg{\cdot}ha^{-1}$ and 4715 $kg{\cdot}ha^{-1}$ in 2007 and 2008, respectively), It was followed by application of enriched poultry manure compost + 3% jeevamrutham spray at 30 & 45 DAT which was on par with application of enriched poultry manure + 3% beejamrutham

spray at 30 & 45 DAT and found significantly superior over rest of the organic supplement combination treatments.Applying enriched FYM + 3% panchagavya spray at 30 and 45 DAT in both years was the second best treatment. In both years, the absolute control showed a lower grain yield. By preventing the entire soluble form from coming into contact with soil and other inorganic constituents, enriched poultry manure compost can supply nutrients in a soluble form for a longer period of time. This reduces fixation and precipitation from the enriched manures, allowing the plant roots to effectively compete with loss mechanisms and absorb more nutrients, ultimately leading to a higher yield (Mohandas 2018) [9]. The high levels of nitrogen in poultry manure and the high levels of macro and micronutrients as well as growth-promoting substances in panchagavya contributed to the higher yield and its characteristics. Additionally, poultry manure generates more humic acid, which forms chelated phosphorus that is soluble in water and facilitates the crop's quick phosphorus release. Prakash (2018) [11] also corroborated these findings.

Influence of Organic Manures on Rice Quality

Higher milling recovery, head rice percentage, and a reduced broken percentage of rice were observed at 30 and 45 days after treatment with enhanced poultry manure compost and 3% panchagavya spray. According to Table 2, the absolute control had a higher proportion of broken rice, a lower percentage of head rice, and a lower milling recovery.

Table 2: Milling characteristics of paddy and physical characteristics of raw rice grain

Treatments	Milling recovery (%)		Head rice recovery (%)		Broken rice (%)		Grain length (mm)		Grain breadth (mm)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Absolute control	56.6	57.8	55.2	57.5	39.8	38.6	4.45	4.73	1.59	1.68
Recommended NPK fertilizers	61.6	63.3	60.4	62.0	36.4	36.0	4.99	5.16	1.81	1.83
Enriched FYM compost	59.1	59.8	58.6	60.1	38.6	37.2	4.76	4.97	1.68	1.75
Enriched poultry manure compost	59.5	62.1	58.9	60.3	38.1	36.9	4.82	5.02	1.76	1.78
Enriched FYM compost + 3% jeevamrutham FS at 30&45 DAT	63.1	65.1	62.5	63.4	35.0	34.6	5.15	5.34	1.86	1.90
Enriched FYM compost + 3% beejamrutham FS at 30&45 DAT	63.0	64.8	62.1	63.0	35.2	35.0	5.13	5.31	1.85	1.88
Enriched FYM compost + 3% panchagavya FS at 30&45 DAT	64.5	66.4	64.3	64.9	34.1	33.5	5.29	5.48	1.90	1.94
Enriched poultry manure compost + 3% jeevamrutham FS at 30&45 DAT	66.7	68.1	64.1	67.3	32.7	32.1	5.73	5.75	1.99	2.01
Enriched poultry manure compost + 3% beejamruthamFS at 30&45 DAT	66.4	67.9	66.0	67.1	32.9	32.4	5.50	5.67	1.95	1.99
Enriched poultry manure compost + 3% Panchagavya FS at 30&45 DAT	68.7	69.4	67.8	68.9	31.5	29.8	5.86	5.98	2.03	2.05
SEd	0.61	0.53	0.65	0.68	0.49	0.43	0.051	0.054	0.012	0.010
CD (P=0.05)	1.26	1.12	1.39	1.28	0.94	0.84	0.106	0.111	0.027	0.021

FYM; Farm yard manure, DAT; Days After Transplanting, FS; Foliar spray

This might be due to better amenability for shelling, good grain size and less number of chalky grains was observed under this treatment. Though N was supplied on equivalent N basis, the enriched poultry manure compost contains more P, K and micronutrients combined with growth promoting substance of panchagavya which might have helped to reduce broken percentage and in turn increased head rice recovery. Grain length and breadth were maximum in enriched poultry manure compost + 3% panchagavya spray at 30 & 45 DAT and it was followed byenriched poultry manure compost + 3% jeevamrutham spray at 30 & 45 DAT which was on par with application of enriched poultry manure + 3% beejamrutham spray at 30 & 45 DAT.Application of poultry manure along with liquid supplement resulted to better physical characteristics of grain (Kenchaiah 1997) [7].

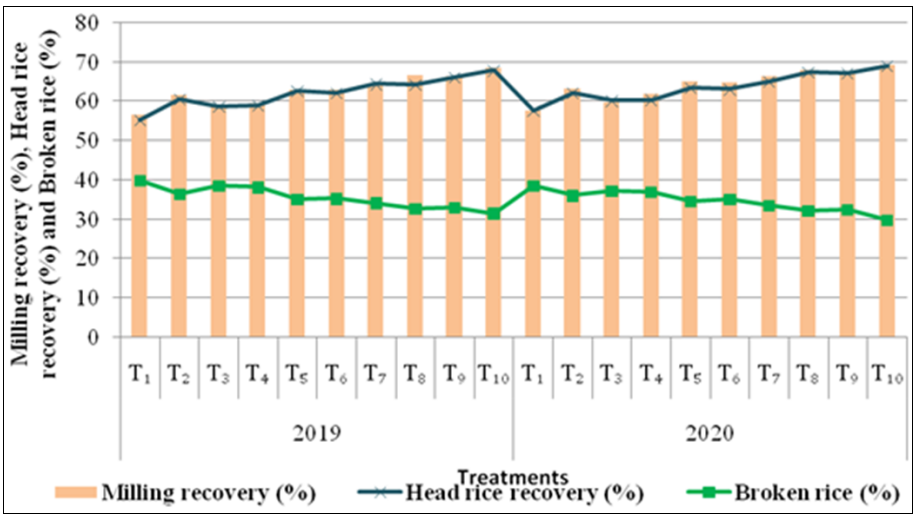

Fig 2: Milling quality of paddy and physical characteristics of raw rice grain

Cooking Qualities of Milled Rice

Higher volume expansion ratios and better water absorption ratios were observed in the enriched poultry manure compost plus 3% panchagavya spray at 30 and 45 DAT. The increased volume expansion and water absorption ratio may be because to the bold rice grain that was seen in these treatments (Yadav and Lourduraj 2006) [18]. In the same organic supplement application, the length-to-breadth ratio increased during cooking (Table 3).

Table 3: Effect of organic supplements on cooking qualities of milled rice (open cooked)

Treatments	Volume expansion ratio		Water absorption ratio		LBAC	
	2019	2020	2019	2020	2019	2020
Absolute control	1.89	1.94	4.01	4.07	3.89	3.92
Recommended NPK fertilizers	2.23	2.30	4.19	4.22	4.02	4.04
Enriched FYM compost	2.06	2.12	4.10	4.15	3.95	3.98
Enriched poultry manure compost	2.07	2.14	4.12	4.16	3.97	3.99
Enriched FYM compost + 3% jeevamrutham FS at 30 & 45 DAT	2.42	2.48	4.26	4.29	4.07	4.09
Enriched FYM compost + 3% beejamrutham FS at 30 & 45 DAT	2.39	2.47	4.35	4.28	4.06	4.08
Enriched FYM compost + 3% panchagavya FS at 30 & 45 DAT	2.59	2.65	4.31	4.35	4.11	4.13
Enriched poultry manure compost + 3% jeevamrutham FS at 30 & 45 DAT	2.79	2.83	4.39	4.43	4.17	4.20
Enriched poultry manure compost + 3% beejamrutham FS at 30 & 45 DAT	2.77	2.82	4.37	4.41	4.15	4.18
Enriched poultry manure compost + 3% Panchagavya FS at 30 & 45 DAT	2.96	2.99	4.45	4.51	4.22	4.25
SEd	0.069	0.071	0.017	0.016	0.014	0.010
CD (P=0.05)	0.145	0.142	0.038	0.035	0.029	0.021

LBAC-Length Breadth ratio After Cooking

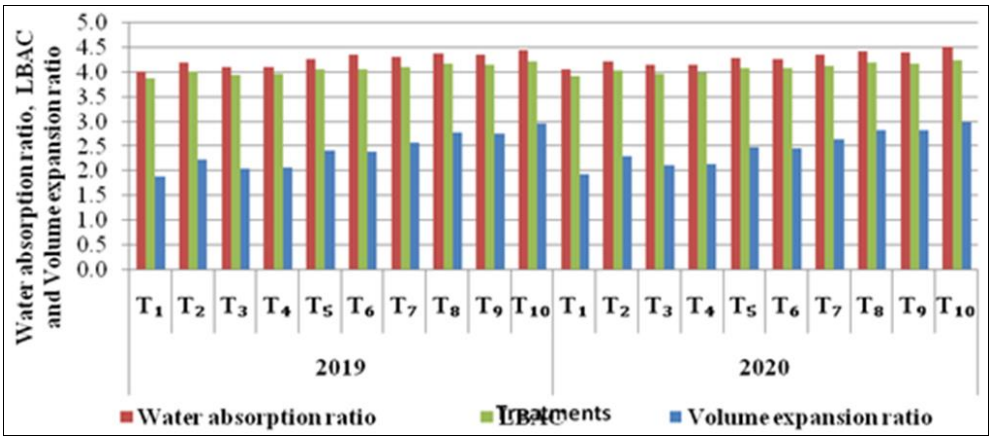

Fig 3: Effect of organic supplements on cooking qualities of milled rice (open cooked)

This feature is seen as desirable in rice of superior quality. After cooking, rice treated with organic additives had a greater L:B ratio than rice treated with inorganic fertilizer (Nguyen 2002) [10]. Absolute control was registered for the smaller LBAC.

In a similar vein, using enriched poultry manure and enriched FYM alone increased the quality features of rice (Hsieh 1995) [6]. Senthil Kumaran and Vadivel (2001) [12] found that rice grown organically had better organoleptic qualities and was of greater eating quality than rice grown conventionally.

Conclusion

From the present investigation, it could be concluded that the application of enriched poultry manure compost + 3% panchagavya spray at 30 & 45 DAT recorded higher yield attributes and grain yield of rice. Improved rice grain quality, in terms of chemical composition, cooking quality and high score of sensory evaluation was achieved under organic supplemental application.

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