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INFLUENCE OF NATURAL AND ORGANIC FARMING SYSTEMS ON GROWTH, YIELD AND ECONOMICS OF *RABI* SORGHUM

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ABSTRACT

Field study was conducted at Instructional Farm, College of Agriculture, Vijayapur, situated in the Northern Dry Zone of Karnataka, during *rabi* season of 2019-20 to study the effect of natural and organic farming systems on growth, yield and economics of *rabi* sorghum. The experiment comprises of twelve treatment combinations with three main plots of different farming systems and four sub plots of graded levels of nutrients along with single control, which is conventional farming with recommended package of practice. The experiment was laid out in strip plot design with single control and replicated thrice. Results revealed that organic production (OP) system resulted in significantly higher growth, yield and yield attributes over remaining farming systems. Among graded levels of nutrients, organics equivalent to 125 per cent recommended N recorded significantly higher growth, yield and yield attributing parameters over remaining graded levels of nutrients and remained at par with organics equivalent to 100 per cent recommended N. Among interactions, OP system equivalent to 125 per cent recommended N recorded significantly higher growth parameters mainly, plant height, leaf area, dry matter accumulation in leaf, stem and reproductive parts, total dry matter production, yield (2584 kg ha^{-1}) and yield attributes like earhead length (25.2 cm), earhead weight plant^{-1} (67.6 g), grain weight earhead^{-1} (51.7 g), 1000 seed weight (34.7 g) over conventional system. Higher gross returns (90683 Rs ha^{-1}) and net returns (64347 Rs ha^{-1}) and B:C ratio (3.44) was also obtained with the same treatment and these economic returns were on par with OP system equivalent to 100 per cent recommended N.

(Key words: Organic production, natural farming, conventional farming, graded levels of nutrients, sorghum, growth, yield, net returns)

INTRODUCTION

Productive agriculture is dependent upon sound farming systems and nutrient management practices. Present day agriculture practices, which produce higher yields, require extensive use of chemical fertilizers which are costly and create environmental problems. Further, the in-discriminate use of chemical fertilizers has an adverse effect on physical, chemical and biological properties of soil, there by affecting the sustainability of crop production, besides cause environmental pollution (Virmani, 1994). Thus, there has been a recent resurgence of importance in environmentally friendly and sustainable natural and organic agricultural systems in the world (Orhan *et al*., 2006). They become popular among the farming community because of their stability in production and soil health maintenance. The crop productivity under natural and organic production systems can be improved through optimizing the nutrient requirement of crops at different stages. This can be achieved through crop residue management and integrated organic nutrition by using different sources of nutrients those have different nutrient release pattern and efficiency. Integrated application of organic manures mainly compost, vermicompost, ghanajeevamruth and gliricidia green leaf manure produced higher yield along with improving soil health. Further, foliar and soil application of liquid organic manures mainly jeevamruth, cowurine and vermiwash meet the nutrient demand of crops with greater nutrient use efficiency.

Among various crops sorghum is an important staple cereal food crop of India, which is drought tolerant and grown on residual moisture conditions under rainfed areas of the country. Besides, major source of staple food for human it also provides a very good quality fodder for animals.In India, sorghum is cultivated over an area of 5.02 million ha with an annual production of 4.83 million tonnes of grain with a productivity of 956 kg ha^{-1} (Anonymous, 2020). The first three largest producing states are

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Maharashtra, Karnataka and Madhya Pradesh. In Karnataka, it is cultivated on an area of 1.09 million ha with an annual production of 1.14 million tonnes of grain with a productivity of 956 kg ha^{-1} (Anonymous,2018). In this context, field trial, was carried out to evaluate different farming systems and nutrient levels in *rabi* sorghum.

MATERIALS AND METHODS

Field study was conducted at Instructional Farm, College of Agriculture, Vijayapur, situated in the Northern Dry Zone of Karnataka (Zone 3) to study the effect of natural and organic farming systems on growth, yield and economics of *rabi* sorghum. The soil of the experimental site was medium deep black, having organic carbon (3 g kg^{-1}) and available N: P_2O_5: K_2O of 165: 23: 420 kg ha^{-1}. The experiment was laid out in strip plot design with single control and replicated thrice. The main plot comprises of three different farming systems as M_1 : Subhas Palekar Natural Farming (SPNF) system (seed treatment with Beejamrutha, nutrients were applied ½ through soil application of Ghanajeevamrutha + ½ through gliricidia leaf manure equivalent to the recommended N + foliar spray of Jeevamrutha @ 10 per cent,), M_2: Intensive natural farming system (seed treatment with Beejamrutha, nutrients were applied ½ through Ghanajeevamrutha + ½ through gliricidia green leaf manure equivalent to the recommended N integrated with FYM @ 2.5 t ha^{-1} + intercropped with one row of sunnhemp @ 30 cm apart as cover crop and mulched later at 30 DAS and foliar spray of Jeevamrutha @ 10 per cent), M_3: Organic production system (seed treatment with *Trichodema*+ *Rhizobium* + PSB, nutrients were applied1/3 through enriched compost (EC) + 1/3 through vermico-mpost (VC) + 1/3 through gliricidia green leaf manure(GLM) equivalent to the recommended N) and foliar application of cow urine @10 per cent and vermiwash @ 5 per cent, and four sub plots comprising of organic and natural nutrient management practices in which nutrients were supplied at graded levels mainly 50, 75, 100 and 125 per cent of the recommended nitrogen equivalent, with a single control, which is conventional farming with recommended package of practices (50: 25 kg N: P_2O_5 ha^{-1} + PSB + *Azospirillum* biofertilizer seed treatment @ 10 g kg^{-1} of seed). At the time of sowing, 100 per cent of recommended dose of nitrogen and phosphorus chemical fertilizers were applied to control treatment. Gliricidia green leaf manure on fresh weight basis, Ghanajeevamruth, FYM, compost and vermicompost all applied as per the treatments at the time of sowing. Jeevamrutha @ 10 per cent, cow urine @10 per cent and vermiwash @ 5 per cent were applied as per the treatments at 20 and 40 DAS. The *rabi* sorghum variety M 35-1 was used and sowing was done on 17th September, 2019 with spacing of 60 cm X 20 cm.

Observationsons of crop growth parameters at harvest, mainly plant height, leaf area, dry matter accumulation in leaf, stem and reproductive parts and total dry matter production and yield attributes mainly earhead weight, grain weight earhead test weight, grain and stover yield, harvest index and economics were recorded. The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was at 5%.

RESULTS AND DISCUSSION

Crop growth

Different farming systems, graded levels of nutrients and their combinations influenced significantly on growth of *rabi* sorghum (Table 1). Organic production (OP) system resulted in significantly higher plant height (187.1 cm), leaf area (27.6 dm^2 $plant^{-1}$), dry matter accumulation (DMA) in leaf (15.98 g $plant^{-1}$), stem (70.23 g $plant^{-1}$) and in reproductive parts (63.9 g $plant^{-1}$)and total dry matter production (TDMP) (150.1 g $plant^{-1}$) as compared to other farming systems evaluated. However, leaf area and DMA in leaf was found on par with SPNF system. Among graded levels of nutrients, organics equivalent to 125 per cent of recommended N recorded significantly higher growth parameters as compared to organics equivalent 50 and 75 per cent of recommended N and remained at par with organics equivalent to 100 per cent recommended N. Among the interactions, OP system equivalent to 125 per cent recommended N (M_3S_4) recorded significantly higher plant height (199.2 cm), as compared to other combinations except SPNF with 125 per cent of the recommended N (M_1S_4). When they are compared with conventional system, M_3S_4, M_1S_4, M_3S_2 and M_3S_3 showed on par results. Significantly higher leaf area (30.0 dm^2 $plant^{-1}$) was recorded with the interaction of M_3S_4 over rest of the combinations and also it was significantly superior to conventional system. Whereas, dry matter accumulation (DMA) in leaf was significantly higher with organic system and SPNF system at all the nutrient levels (M_3S_1, M_3S_2, M_3S_3 and M_3S_4) as compared to intensive natural farming system at all the nutrient levels (M_1S_1, M_1S_2, M_1S_3, M_1S_4) and were at par with the conventional farming system. Superiority in plant height, leaf area and DMA in leaf with organic and SPNF systems with higher levels of nutrients was attributed to both soil and foliar nutrition to the plants as required at different stages of plant phenology. The lower plant height and leaf area with intensive natural farming system was attributed to the suppression of growth of sorghum at initial stages by the sunnhemp cover crop grown in between two sorghum rows compete for moisture up to 30-35 DAS under rainfed conditions.

In organic system increased growth parameters might be due to foliar spray of vermiwash at 5 per cent and cow urine 10 per cent at 20 and 40 DAS along with application of compost, vermicompost and gliricidia which have different nutrient release pattern and supplies the required nutrients for crop growth through the process of mineralization at different stages of crop growth. The positive effect of cowurine and vermiwash might be due to growth

promoting substances such as IAA, GA, cytokinin, essential enzymes and nitrogen as nitrogenous excretory product (Esakkiammal *et al.,*2015). Cowurine contains various enzymes cocktail of protease, amylase, urease and phosphatase. These influences the chlorophyll content in leaves which enhances higher leaf area resulted in production of more photo assimilates and their accumulation. It further increased the TDMP, which reflected in taller plants,greater yield attributes and higher yield.

Among the interactions, dry matter accumulation in stem was significantly higher with organic production system with 125 per cent of recommended N equivalent. The combinations, SPNF, intensive NF and OP systems with 100 and 125 per cent of recommended N produced on par results with the conventional farming system. These results showed organic and natural systems supplemented with 100 per cent and 125 per cent of recommended N meet the nutrient demand of the crop and better availability of soil moisture. Dry matter accumulation in reproductive parts was significantly higher with M_3S_4 over rest of the treatments and conventional farming system. The conventional farming system was next best was at par with M_3S_2 and M_3S_3 combinations. Total dry matter production (TDMP) was significantly higher with M_3S_4 over rest of the combinations. Further, conventional system with M_3S_4, M_1S_4, $M_3S_1$and M_3S_2 combinations, the 100 per cent and 125 per cent of N substitution in organic and natural system met the nutritional demand of crops with the accrued benefits on soil organic matter and soil quality.

Yield and yield attributes

Yield is the function of sum total of growth and development at different phenological stages of the plant and is the cumulative expression of different yield attributes. Significantly higher grain yield (2389 kg ha^{-1}) was produced with organic production system (M_3) as compared to INF (M_2) system (1766 kg ha^{-1}) and SPNF (M_1) system (1994 kg ha^{-1}) which were on par with each other. Similarly, the grain yield of soybean, wheat and soybean equivalent yield were significantly higher in combined use of organic manures plus fermented organics as compared to natural fermented organics alone and was on par with RDF+FYM (Shwetha *et al.,* 2009).In groundnut organics equivalent to 100 per cent recommended phosphorus produced significantly higher yield as compared to inorganics alone and on par with integrated (RDF+FYM) conventional system (Babalad *et al.,* 2009). Irrespective of farming systems, nutrients equivalent to 125 per cent of recommended N (S_4) recorded significantly higher grain yield (2197 kg ha^{-1}) as compared to nutrients equivalent to 50 per cent of recommended N (S_1)but was on par with nutrients equivalent to 75 (S_2) and 100 (S_3) per cent of recommended N (2029 and 2071 kg ha^{-1} respectively)-. Among the interactions of farming systems and graded level of nutrients, M_3S_4 recorded significantly higher grain yield (2584 kg ha^{-1}) over other combinations, except M_3S_3 (2425 kg ha^{-1}) which was on par. M_3S_4 recorded significantly higher grain yield compared to conventional practice (2100 kg ha^{-1}). Furt her the later treatment was at par with the interactions of all farming systems and graded level of nutrients. On medium deep black soils of transitional tract of Dharwad, combined application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 100 per cent RDF with foliar spray of panchagavya @ 5% recorded significantly higher kapas yield and mean boll weight of cotton (Channagouda *etal.,*2015). Similarly, in maize application of compost as organic amendment produced higher yield as compared to inorganic conventional system (Amanullah and Imarn Khan, 2017).

In *rabi* sorghum, yield is the product of number of seeds $earhead^{-1}$, test weight and grain weight $earhead^{-1}$. OP system resulted in significantly higher yield attributes over remaining farming systems except 1000 seed weight which was on par with SPNF system. Among graded levels of nutrients, organics equivalent to 125 per cent recommended N recorded significantly higher earhead length, earhead weight, grain weight $earhead^{-1}$ and 1000 seed weight over organics equivalent to 50 and 75 per cent recommended N and it was comparable with organics equivalent to 100 per cent recommended N. Among these combinations, OP system equivalent to 125 per cent recommended N recorded significantly higher yield attributes like earhead length (25.2 cm),earhead weight $plant^{-1}$ (67.6 g),grain weight $earhead^{-1}$ (51.7 g) and 1000 seed weight (34.7 g) over other combinations and control. The next best was M_3S_3 which was on par with conventional farming system.Whereas, the M_3S_4produced 23 per cent higher grain yield of *rabi* sorghum over conventional farming system (Table 2). Application of FYM (1/3)+ Vermicompost (1/3) + glyricidia green leaf manure (1/3) equivalent to 100% RDP and foliar spray of panchagavya (3%) at flower initiation and 15 DAF recorded significantly more number of pods $plant^{-1}$, pod weight $plant^{-1}$ and 100 pod weight (Babalad *et al.*, 2009) This increases in yield is mainly due to the substantial release of N, P_2O_5 and K_2O and other nutrients from the processes of mineralization of organic materials, which in turn increased the available pool of nutrients at higher levels of organics (S_3 and S_4) throughout the growing period.In greengram Fazulla *et al.,* (2017) under dryland conditions noticed soil application of organic manures and liquid organic foliar sprays at flower initiation and 15 days after flowering (DAF) significantly enhanced the seed yield and seed quality parameters of green gram. Application of FYM (1/3)+ Vermicompost (1/3)+ glyricidia leaf manure (1/3) equivalent to 100% RDF and foliar spray of panchagavya (3%) at flower initiation and 15 DAF recorded significantly more number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, seed weight $plant^{-1}$and seed yield with concomitant higher seed quality para-meters. Further,vermicompost supply the macro and micronutrients in the readily available form to the plants, react with native soil nutrients in a way that enhance their availability to crops.Higher yield attributing characters in above interactions could be attributed to increase in the rate of photosynthesis coupled with efficient translocation of photosynthates from leaf and stem (source) to economical

Table 1. Influence of different farming systems, graded levels of nutrients and their combinations on growth of *rabi* sorghum at harvest

Treatments	Plant height (cm)	Leaf area (dm^2 $plant^{-1}$)	Dry matter accumulation in leaf (g $plant^{-1}$)	Dry matter accumulation in stem (g $plant^{-1}$)	Dry matter accumulation in reproductive parts (g $plant^{-1}$)	Total dry matter production (g $plant^{-1}$)
Farming systems						
M_1	175.8	25.9	15.26	60.01	53.7	128.9
M_2	167.8	24.5	12.5	56.04	50.6	119.1
M_3	187.1	27.6	15.98	70.23	63.9	150.1
SEm ±	0.87	0.8	0.85	1.59	0.6	1.9
LSD(±0.05)	3.41	3.0	3.35	6.24	2.5	**7.7**
Graded levels of nutrients						
S_1	162.7	25	13.92	56.28	52.2	122.4
S_2	173.3	25.5	14.55	60.15	54.7	129.4
S_3	183	26	14.85	63.42	58	136.3
S_4	188.7	27.5	14.99	68.53	59.4	142.9
SEm ±	2.79	0.3	0.27	3.31	0.7	3.5
LSD(±0.05)	9.67	1.2	0.95	11.47	2.4	12.1
Combination						
M_1S_1	159.9	24.4	14.76	52.38	50.3	117.4
M_1S_2	171.1	26	15.24	56.51	53	124.8
M_1S_3	182.6	26.2	15.4	61.27	55.5	132.1
M_1S_4	189.5	27.1	15.63	69.88	55.9	141.4
M_2S_1	155.6	24.6	11.41	52.38	46.8	110.6
M_2S_2	165.9	24	12.44	55.18	48.1	115.8
M_2S_3	172.5	24.3	13.03	57.07	52.7	122.8
M_2S_4	177.3	25.4	13.11	59.52	54.8	127.4
M_3S_1	172.6	26.1	15.59	64.07	59.4	139.1
M_3S_2	182.9	26.6	15.97	68.76	62.8	147.5
M_3S_3	193.7	27.6	16.11	71.91	65.9	153.9
M_3S_4	199.2	30	16.23	76.18	67.6	160
SEm ±	0.89	0.3	0.29	1.06	0.3	1.2
LSD(±0.05)	2.81	1.2	1.08	3.43	1.0	3.9
Control	187.7	26.7	15.01	69.81	64.3	149.1
SEm ±	3.91	1.1	0.90	4.20	1.1	4.6
LSD(±0.05)	11.40	3.1	2.63	12.27	3.2	13.3

M_1 : Subhas Palekar natural farming system

M_2 : Intensive natural farming system

M_3: Organic production system

Control : Conventional farming system

S_1: 50 per cent of the recommended N

S_2 :75 per cent of the recommended N

S_3: 100 per cent of the recommended N

S_4 :125 per cent of the recommended N

Table 2. Influence of different farming systems, graded levels of nutrients and their combinations on yield and yield parameters of *rabi* sorghum

Treatments	Earhead length (cm)	Earhead weight (g plant^{-1})	Grain weight (g earhead-^{1})	1000 seed weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
Farming systems								
M_1	19.8	53.7	39.7	31.36	1994	4770	6764	0.29
M_2	17.6	50.6	35.9	29.42	1766	4414	6179	0.29
M_3	23	63.9	48.1	32.26	2389	5181	7570	0.32
SEm ±	0.3	0.6	1.2	0.68	96	133	221	0.005
LSD(±0.05)	1.3	2.5	4.7	2.69	376	521	868	0.02
Graded levels of nutrients								
S_1	19	52.2	37.4	29.4	1902	4545	6447	0.29
S_2	19.6	54.7	39.9	30.13	2029	4744	6773	0.3
S_3	20.2	58	43.1	31.44	2071	4839	6910	0.3
S_4	21.7	59.4	44.5	33.07	2197	5024	7221	0.3
SEm ±	0.5	0.7	0.4	0.74	61	139	183	0.006
LSD(±0.05)	1.7	2.4	1.4	2.56	211	477	632	-
Interactions								
M_1S_1	18.7	50.3	36.3	29.5	1828	4583	6411	0.28
M_1S_2	19.2	53	39.1	29.93	1981	4624	6605	0.3
M_1S_3	19.6	55.5	41.5	32.33	2030	4815	6845	0.3
M_1S_4	21.6	55.9	41.7	33.67	2138	5058	7196	0.3
M_2S_1	16.7	46.8	32	29	1684	4070	5753	0.29
M_2S_2	17.2	48.1	33.4	28.83	1754	4369	6123	0.29
M_2S_3	18.1	52.7	37.9	29	1758	4486	6244	0.28
M_2S_4	18.3	54.8	40	30.83	1867	4731	6598	0.28
M_3S_1	21.6	59.4	43.8	29.7	2194	4984	7177	0.3
M_3S_2	22.3	62.8	47.2	31.63	2352	5239	7591	0.31
M_3S_3	23	65.9	49.9	33	2425	5217	7642	0.32
M_3S_4	25.2	67.6	51.7	34.7	2584	5285	7869	0.33
S.Em ±	0.2	0.3	0.4	0.44	53	86	133	0.003
LSD(±0.05)	0.7	1	1.4	1.43	176	280	436	0.010
Control	23	64.3	47.6	30.5	2100	5152	7252	0.29
SEm ±	0.7	1.1	1.2	1.41	162	274	410	0.011
LSD(±0.05)	2.1	3.2	3.4	4.12	472	798	1198	0.032

M_1 : Subhas Palekar natural farming system
M_2 : Intensive natural farming system
M_3: Organic production system
Control : Conventional farming system

S_1: 50 per cent of the recommended N
S_2 :75 per cent of the recommended N
S_3: 100 per cent of the recommended N
S_4 :125 per cent of the recommended N

Table 3. Influence of different farming systems, graded levels of nutrients and their combinations on economics of *rabi* sorghum

Treatments	Gross returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	B : C ratio
Farming systems				
M_1	71364	24694	46670	2.89
M_2	63563	26672	36891	2.38
M_3	84416	24840	59576	3.40
SEm ±	3199	-	3199	0.13
LSD(±0.05)	12560	-	12560	0.51
Graded levels of nutrients				
S_1	68043	23883	44160	2.86
S_2	72393	24898	47495	2.92
S_3	73880	25905	47975	2.86
S_4	78142	26923	51219	2.91
SEm ±	2060	-	2040	0.08
LSD(±0.05)	7129	-	7038	0.28
Interactions				
M_1S_1	65824	23161	42663	2.84
M_1S_2	70659	24184	46475	2.92
M_1S_3	72570	25205	47365	2.88
M_1S_4	76404	26227	50177	2.91
M_2S_1	60333	25139	35194	2.40
M_2S_2	63122	26162	36960	2.41
M_2S_3	63460	27183	36277	2.33
M_2S_4	67338	28205	39133	2.39
M_3S_1	77971	23348	54623	3.34
M_3S_2	83400	24349	59051	3.43
M_3S_3	85609	25327	60282	3.38
M_3S_4	90683	26336	64347	3.44
S.Em ±	1788	-	1788	0.07
LSD(±0.05)	5912	-	5912	0.23
Control	64895	24394	40501	2.66
SEm ±	5431	-	5431	0.21
LSD(±0.05)	15852	-	15852	0.62

M_1 : Subhas Palekar natural farming system

M_2 : Intensive natural farming system

M_3: Organic production system

Control : Conventional farming system

S_1: 50 per cent of the recommended N

S_2 :75 per cent of the recommended N

S_3: 100 per cent of the recommended N

S_4 :125 per cent of the recommended N

part (sink). This could be supported by growth analysis studies showed that, economic yield depends not only on the greater dry matter production plant^{-1}, but also its translocation into economically beneficial parts (Krishnamurthy *et al.,* 1973).This is indicated by higher harvest index with organic production system at higher levels of nutrient substitution (M_3S_3 and M_3S_4) than conventional system.

Economics

Among different farming systems,OP system recorded significantly higher gross returns, net returns and B:C (Rs.84416 ha^{-1}, Rs.59576 ha^{-1} and 3.40, respectively) over INFS system (Rs.63563 ha^{-1}, Rs.36891 ha^{-1} and 2.38, respectively) and SPNF system (Rs.71364 ha^{-1}, Rs.46670 ha^{-1} and 2.89, respectively) except B:C ratio was on par with SPNF system was mainly due to reduced cost of cultivation in SPNF system compared to OP system. Among the graded levels of nutrients,significantly higher gross returns (Rs.78142 ha^{-1}) and net returns (Rs.51219 ha^{-1}) was noticed with organics equivalent to 125 per cent recommended N as compared to organics equivalent to 50 per cent recommended N but was on par with organics equivalent to 75 and 100 per cent recommended N. However, B:C ratio did not differ significantly among the organics at different levels of nutrients M_3S_3, M_3S_2 and M_3S_1 and significantly superior over other interactions.The conventional system noticed significantly lower gross returns andnet returns, as compared to the interactions M_3S_2, M_3S_3, M_3S_4 and B:C ratio as compared to the interactions M_3S_1 M_3S_2, M_3S_3,and M_3S_4 and on par with rest of the interactions. This might be due to variation in yield among the systems and also lower cost of cultivation in INF and SPNF systems. Higher growth, yield, yield parameters and economics can be obtained in *rabi* sorghum with combined application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 125 per cent recommended N with foliar spray of cow urine @10 per cent and vermiwash @ 5 per cent and economics was found on par with OF system equivalent to 100 per cent recommended N. The organics and natural sources of nutrients equivalent to 75 to 125 per cent recommended N with premium price for *rabi* sorghum, was found to be more profitable as compared to conventional *rabi* sorghum and it is environment friendly, fair with labour, energy saving and quality produce.

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