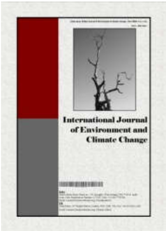

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Eco-Friendly Management Practices on Quality Characteristics of Transplanted Rice (*Oryza sativa* L.) as Influenced by Organic Manures

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted at the farm of Tamil Nadu Agricultural University, Coimbatore during *kharif* season (Spring) to study the effect of eco-friendly management practices on quality characteristics of transplanted lowland rice. Rice CO(R) 48 was used as a test variety. The experiment was laid out in randomized block design (RBD) with three replications and nine treatments which are T_1 –100 % N through dhaincha + balance P and K through inorganic fertilizers, T_2 – 50 % N through dhaincha + balance N, P and K through inorganic fertilizers, T_3 –100 % N through vermicompost + balance P & K through inorganic fertilizers, T_4 –50 % N through vermicompost + balance N, P and K through inorganic fertilizers, T_5 –100 % NPK (150 : 50 : 50 kg ha^{-1}) through inorganic fertilizers, T_6 –100 % NPK through inorganic fertilizers + 12.5 t farmyard manure, T_7 – 100 % NPK through inorganic fertilizers + 6.25 t dhaincha, T_8 – 100 % NPK through inorganic fertilizers + 5 t vermicompost, T_9 – Control. The results revealed that higher quality characteristics of rice including physical parameters (grain length, grain breadth and L/B ratio), chemical parameters (moisture, protein, carbohydrate, amylose, fat and fibre) and cooking quality

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were obtained with application of 100 % N through dhaincha + balance P & K through inorganic fertilizers followed by application of 100 % NPK through inorganic fertilizers + 6.25 t dhaincha and it was par with application of 100 per cent NPK through inorganic fertilizers + 5 t ha^{-1} vermicompost and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure. Lower quality characteristics of rice were registered in absolute control.

Keywords: Dhaincha; FYM; rice; quality characteristic and vermicompost.

1. INTRODUCTION

Rice is an important cultivated food crop that feeds more than half of the world's population [1]. The slogan “Rice is life” is most appropriate for India, as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural households [2]. Even though the area under rice cultivation is large, Grain quality of rice is very complicated, but an important properties in many areas for rice production in the world, mainly defined by four constituents: namely, milling, cooking, appearance and nutritional quality [3]. Among environmental factors, nutrient sources supplied during the life cycle of the crop provides to the physico-chemical quality of the produce [4].

High cost of fertilizer and the low purchasing capacity of the small and marginal peasants of the country restrict the use of fertilizer inputs [5]. The increasing demand for rice grain production has to be achieved by using limited available resources in a sustainable manner. In India, about 40 per cent of the total plant nutrients are consumed by rice crop alone [6]. Though the use of fertilizers per unit area of rice is higher, the fertilizer use efficiency is generally low [1].

The current challenge to rice improvement programs is to feed the ever-growing population with diminishing natural resources and environmental fluctuations on one-hand and varieties that have grain quality that the consumer demands, on the other. The economic value and the consumer acceptance/preference of a rice variety depend on rice grain quality. Rice grain quality is a complex trait and is therefore difficult to define comprehensively [3]. Rice quality comes from a polygenic group of traits that are affected by environmental factors, crop management and the resulting interactions among these. It involves the physical appearance, milling quality, cooking, sensory and nutritional value. The emphasis laid on each of these traits depends on regional consumer preference, market demand, and intended functional use [7].

Organic manure decomposting is a biological process in which organic biodegradable wastes are converted into hygienic, humus rich product (compost) for use as a soil conditioner and an organic fertilizer [8]. The using of organic materials it could help to solve pollution problems caused that by agro-industrial wastes. Adding much nitrogen fertilizer, whether in the form of organic matter or chemical fertilizer, some of the excess nitrogen is converted to nitrates, which are harmful to human health [4].

Use of organic manure, green manuring, crop residues along with inorganic fertilizers not only reduce the demand for inorganic fertilizers but also increases the efficiency of applied nutrients due to their favourable effect on physical, chemical and biological properties of soil [9]. An appropriate combination of organic and inorganic nutrient sources was found toenhance the quality characteristics of rice including physical parameters, chemical parameters and cooking quality of transplanted lowland rice.

2. MATERIALS AND METHODS

In Tamil Nadu, medium duration paddy cultivation practices followed in *kharif* season due to the optimum climatic condition. This field experiment trail was conducted at Wetland farm of Tamil Nadu Agricultural University, Coimbatore during August to December, 2019 (120 days). The initial analysis of the soil of the experimental site revealed that the soil was slightly alkaline (pH = 7.85) with low in soluble salts (EC = 0.42 dSm^{-1}), medium in organic carbon content (0.58 per cent), low in available N (216 kg ha^{-1}), medium in P_2O_5 (16.2 kg ha^{-1}) and high in K_2O (426 kg ha^{-1}). These soil parameters were analyzed before transplanting of the experiment site. The irrigation water was found to be neutral in reaction (pH = 7.6) with medium level of the soluble salts (EC = 1.18 dSm^{-1}) [10].

The maximum and minimum temperature ranged from 29.0 to 32.7°C and 19.2 to 23.7°C, respectively. With regard to relative humidity, there was a fluctuation from 77.5 to 94 per cent (0722 hours) and from 49.6 to 77.3 per cent (1422 hours).There was a total rainfall of 110 mm was received in 16 rainy days. The evaporation and bright sunshine hour's day^{-1} ranged from 2.8 to 6.6 mm and 3.1 to 7.4 hours, respectively [11]. The study was conducted with nine treatments which are T_1 –100 % N through dhaincha + balance P and K through inorganic fertilizers, T_2 – 50 % N through dhaincha + balance N, P and K through inorganic fertilizers, T_3 –100 % N through vermicompost + balance P & K through inorganic fertilizers, T_4 –50 % N through vermicompost + balance N, P and K through inorganic fertilizers, T_5 –100 % NPK (150 : 50 : 50 kg ha^{-1}) through inorganic fertilizers, T_6 –100 % NPK through inorganic fertilizers + 12.5 t farmyard manure, T_7 – 100 % NPK through inorganic fertilizers + 6.25 t dhaincha, T_8 – 100 % NPK through inorganic fertilizers + 5 t vermicompost, T_9 – Control. The test crop CO(R) 48 characters was given in Table 1.

Table 1. Characteristics of CO (R) 48 rice variety

Particulars	Rice CO (R) 48
Parentage	CO 43 / ASD 19
Duration (days)	130 - 135 days
Average yield (kg ha^{-1})	6007
1000 grain weight (g)	18.0
Grain L/ B ratio	2.79
Grain type	Medium slender
Morphological characters	
Habit	Medium tall
Leaf sheath	Green
Auricle	Pale green
Panicle	Long, compact, droopy
Rice colour	Straw
Grain size (mm)	
Length	5.30
Breadth	1.90
Thickness	1.22

2.1 Quality Characteristics of Rice

2.1.1 Milling quality

The rough rice (paddy) was cleaned, dried to 14 per cent moisture and dehulled with an Mc Gill laboratory sheller [12]. 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.

2.1.2 Milling recovery percentage

The milling recovery percentage was estimated as follows [12].

$$\text{Milling recovery percentage} = \frac{\text{Total milled rice}}{Total\ rough\ rice} x\ 100$$

2.1.3 Head rice recovery percentage

Head rice recovery percentage was estimated as below [12].

$$\text{Head rice recovery percentage} = \frac{\text{Total head rice}}{\text{Total rough rice}} x\ 100$$

2.1.4 Broken percentage

Broken rice percentage is defined as the percentage of broken rice to the weight of total quantity of rice obtained by shelling [12].

$$\text{Broken rice (\%)} = [\ W_2/\ (W_1+W_2)]\ x\ 100$$

Where,
W_1 -Weight of whole rice in the sample (g), and
W_2 -Weight of broken rice in the sample (g).

2.1.5 Co-efficient of shelling

The Co-efficient of shelling (C) was calculated with the following formula [12].

$$C = (W - W_1) / W$$

Where,
W - Total quantity of shelled paddy (g), and
W_1 - Weight of unshelled paddy (g).

2.1.6 Effectiveness of shelling

The effectiveness of shelling (ES) was calculated with the following formula [12].

$$ES = C\ x\ H$$

Where,
C - Co-efficient of shelling, and
H - Head rice percentage.

2.1.7 Physical parameters

The rice grains were cleaned manually to remove foreign matters such as stones, sand, clay particles, shrivelled, discoloured and infected grains. The following physical parameters were studied to evaluate the quality of rice.

2.1.8 Length

The length was estimated by the method described by Khan and Ali [12]. Ten rice grains of uniform size were kept length-wise on a graph paper and the mean length was me measured and expressed in mm.

2.1.9 Breadth

The breadth was estimated by the method described by Khan and Ali [12]. Ten rice grains of uniform size were kept breadth-wise on a graph paper and the mean breadth was measured and expressed in mm.

2.1.10 Length breadth (L : B) ratio

The data on measured length and breadth for the individual sample used to calculate L:B ratio.

2.1.11 Chemical parameters

Rice samples of each treatment were cleaned by removing stones and other foreign particles. Good grains were powdered and used for chemical analysis.

2.1.12 Moisture

Five-gram samples were placed in a moisture weighing bottle and kept in hot air oven maintained at 105°C. After 16+1 or 16-1 hours of drying, they were cooled in a desiccator for 30 minutes. The weight of the seeds before and after drying was recorded and expressed in gram. The moisture content of the seed was calculated using the following formula [13].

$$\text{Moisture content (\%)} = \frac{M2 - M3}{M2 - M1} x\ 100$$

Where,

- M_1 Weight of the weighing bottle alone,
- M_2 Weight of bottle + seed sample before drying, and
- M_3 Weight of bottle + seed sample after drying.

2.1.13 Fat content

Fat was estimated as crude ether extract of the dry material. Fat content in per cent was calculated by the following formula [14].

$$\text{Fat content in percentage} = \frac{\text{Weight of ether extract}}{\text{Weight of the sample}} x\ 100$$

2.1.14 Protein

The protein content of rice samples was estimated as per the method suggested by Lowry [15]. The estimation of protein was based on the development of blue color by the hydroxyl groups present in the amino acids with the folin-Cocteau phenol reagent. The protein content of the sample was expressed as a percentage.

2.1.15 Carbohydrate

Carbohydrate content was estimated from the samples of each treatment by anthrone method as suggested by Hedge and Hofreiter [16] and expressed as percentage.

2.1.16 Amylose content and Fibre

The method suggested by Sadasivam and Manickam [17] was followed in determining amylose and fibre content.

2.1.17 Cooking quality

2.1.17.1 Optimum cooking time

The time taken for cooking was estimated by the method described by Jayachandran [2]. Five gram of sample was taken in a boiling test tube. To this, 35 ml of water was added and placed in a boiling water bath. A few rice grains were periodically withdrawn and pressed between two slides and the cooking time was adjusted to be complete when white chalky spots had disappeared.

2.1.17.2 Volume expansion ratio

The volume expansion ratio was estimated by the method described by Khan and Ali [12]. It is the ratio between the cooked volume to the uncooked. Five gram of rice was weighed and added in a boiling test tube, then the level was marked. It was cooked by adding water and the level of rice was also marked. The volume was measured by using water displacement method.

2.1.17.3 Water absorption ratio

The water absorption ratio was estimated by the method described by Khan and Ali [12]. It is the ratio between the weight of the cooked rice to the uncooked.

2.1.17.4 Kernel length and breadth after cooking

Ten normal milled grains are presoaked to 10 to 30 minutes and placed directly into boiling water either by direct dropping or in a wire cage or basket until its optimum cooking time. The length and breadth of cooked rice are measured and the average is worked out.

$$\text{Linear elongation ratio (LER)} = \frac{\text{Length of cooked rice}}{\text{Length of raw rice}}$$

$$\text{Breadth wise expansion ratio (BER)} = \frac{\text{Breadth of cooked rice}}{\text{Breadth of raw rice}}$$

$$\text{Length breadth ratio after cooking (LBAC)} = \frac{\text{Kernel length after cooking}}{\text{Kernel breadth after cooking}}$$

3. RESULTS AND DISCUSSION

3.1 Milling Recovery and Whole Rice

The treatments imposed did not significantly influence the milling recovery percentage. However, the milling recovery was higher (69.2) with 100 per cent N through dhaincha + balance P & K through inorganic fertilizers in all the treatments except absolute control Table 2.

Application of 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T_1) registered with more weight of whole rice (46.8 g) followed by 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha (T_7) and it was comparable with 100 per cent NPK through inorganic fertilizers + 5 t Vermicompost (T_8) and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure (T_6). Lower weight of whole rice (34.6 g) was registered in absolute control (T_1). This might be due to better amenability for shelling good grain size and less number of chalky grains. Though N was supplied N equivalent basis, the organic manures contains more P, K and micronutrient which might have helped to increased milling recovery percentage [18].

3.2 Unshelled Paddy, Broken rice and Effectiveness of shelling

The treatments imposed had influenced on weight of unshelled paddy, broken rice percentage and effectiveness of shelling percentage Table 2. The absolute control (T_9) had shown higher Unshelled Paddy (11.5 g) and broken rice percentage (41.5) and lower broken rice percentage (31.6) and unshelled Paddy (5.95 g) was recorded with 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T_1). Among the other treatments, 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha(T_7) noticed highest unshelled Paddy and broken rice percentage and it was on par with 100 per cent NPK through inorganic fertilizers + 5 t Vermicompost (T_8) and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure (T_6). Invariably all the organic treatments resulted with in a lesser weight of unshelled paddy and broken rice percentage when compared with recommended dose of fertilizer treatment and absolute control. Higher effectiveness of shelling percentage (58.9) was registered with 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T_1) and followed by 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha(T_7) and it was comparable with 100 per cent NPK through inorganic fertilizers + 5 t Vermicompost (T_8) and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure (T_6). This might be due to better amenability for shelling good grain size and less number of chalky grains. Though N was supplied N equivalent basis, the organic manures contains more P, K and micronutrient which might have helped to reduce broken percentage and in turn increased head rice recovery. Lower effectiveness of shelling percentage (44) was registered in absolute control. This might be due to no supplement of nutrient either through organic or inorganic sources [18].

3.3 Head Rice Recovery and Co-Efficient of Shelling

The treatments imposed did not significantly influence the head rice recovery percentage and Co-efficient of shelling Table 2. However, milling quality character was higher in all the organic treatments except absolute control.

3.4 Physical Characteristics

The treatments imposed did not significantly influence the grain length, grain breadth and L/B ratio Table 3. Whereas, Application of 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T1) was recorded statistically higher grain length (5.15 mm), grain breadth (1.92 mm) and L/B ratio (2.79) compare than other treatments. These treatments had

Table 2. Influence of sustainable nutrient management practices on milling quality of raw paddy

Treatments	Milling recovery (%)	Whole rice (g)	Unshelled paddy (g)	Head rice recovery (%)	Broken rice (%)	Co-efficient of shelling	Effectiveness of shelling (%)
T_1	69.2	46.8*	5.95	68.4	31.6	0.88	58.9*
T_2	65.7	40.8	9.20	62.8	35.7	0.84	52.5
T_3	66.7	41.5	8.20	63.7	34.5	0.85	53.7
T_4	64.5	40.3	9.45	62.1	36.4	0.83	51.4
T_5	63.9	39.8	10.20*	60.2	38.2	0.81	50.5
T_6	66.8	41.7	6.88	64.1	33.1	0.86	54.1
T_7	67.6	42.3	6.52	65.3	32.4	0.87	55.8
T_8	67.3	41.9	6.72	64.8	32.9	0.86	53.9
T_9	61.9	34.6	11.50*	58.6	41.5*	0.74	44.0
SEd	6.4	3.8	0.88	5.8	3.7	0.08	5.1
CD (p=0.05)	NS	7.8	1.83	NS	7.5	NS	10.4

** Significant at 5 % level*

Table 3. Influence of sustainable nutrient management practices on physical characteristics of raw rice grain

Treatments	Grain length (mm)	Grain breadth (mm)	L/B ratio
T_1	5.15	1.92	2.79
T_2	5.04	1.86	2.75
T_3	5.05	1.87	2.76
T_4	5.03	1.85	2.74
T_5	5.02	1.82	2.72
T_6	5.08	1.89	2.77
T_7	5.09	1.90	2.78
T_8	5.05	1.88	2.76
T_9	5.00	1.78	2.68
SEd	0.50	0.19	0.27
CD (p=0.05)	NS	NS	NS

better yield compounds like number of tillers m^{-2}, grains $panicle^{-1}$ and grain filling percentage which might have influenced these parameters. Application of organic manures resulted to better physical characteristics of grain, which was also reported by Kenchaiah [18]. Absolute control (T_9) registered lower grain length (5 mm), grain breadth (1.78 mm) and L/B ratio (2.68). However, all the physical characteristics were higher in all the treatments except absolute control.

3.5 Chemical Composition

The chemical composition like protein, carbohydrates, amylose content, fat and fibre are presented in Table 4. Application of 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T_1) registered with higher values of protein (7.16 %), carbohydrates (78.28%), amylose content (26.82 %), fat (0.58 %) and fibre (0.229 %) which was followed by 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha(T_7) and it was comparable with 100 per cent NPK through inorganic fertilizers + 5 t Vermicompost (T_8) and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure (T_6). All these characters were lower in absolute control. Nitrogen being an important element and constituent of the amino acids and protein probably, the increased uptake of N might have resulted in the increment of the crude protein content. This might have lead to accumulation of higher quantities of seed components like calcium carbonate and increased the lipid metabolism which helps in increasing the protein content in seed. Higher and proper nutrition through the organic matter resulted with ensured supply of nutrients might have lead to increase in total amylase content and crude protein [19].

3.6 Cooking Characteristics of Milled Rice

The volume expansion ratio (3.24) and water absorption ratio (4.68) was higher with application of 100 per cent N through dhaincha + balance P & K through inorganic fertilizers (T_1) followed by 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha (T_7) with 3.00 of volume expansion ratio 4.33 of water absorption ratio and it was comparable with 100 per cent NPK through inorganic fertilizers + 5 t Vermicompost (T8) and 100 per cent NPK through inorganic fertilizers + 12.5 t farmyard manure (T6). The lowest values were registered with absolute control. Bold rice grain was observed in the INM and all the organic treatments which may be due to higher volume expansion and water absorption ratio. This statement is also supported by Yadav and Lourduraj [20]. The cooking time was not significantly influenced by the different treatments, indicating no relationship of cooking time with the sources of nutrients.

The treatments imposed did not significantly influence the linear elongation ratio, breadth wise elongation ratio, length breadth ratio after cooking Table 5. However, Cooking characteristics of milled rice was higher in application of 100 per cent N through dhaincha + balance P & K through inorganic fertilizersfollowed by 100 per cent NPK through inorganic fertilizers + 6.25 t dhaincha (T_7) whereas, lower the length breadth ratio after cooking was recorded in absolute control .This character is considered as desirable trait in high quality rice. Application of organic manures gave a higher L:B ratio of rice after cooking than with inorganic fertilizers [21].

Table 4. Influence of sustainable nutrient management practices on chemical composition of rice

Treatments	Moisture (%)	Protein (%)	Carbohydrate (%)	Amylose (%)	Fat (%)	Fibre (%)
T_1	12.4	7.16	78.28	26.82	0.58	0.229
T_2	12.2	7.04	75.40	24.47	0.53	0.205
T_3	12.4	7.07	76.60	24.53	0.52	0.207
T_4	12.1	7.02	75.02	22.43	0.53	0.198
T_5	12.2	6,75	74.50	21.67	0.52	0.193
T_6	12.3	7.09	76.80	24.65	0.51	0.209
T_7	12.3	7.14	77.56	25.54	0.56	0.218
T_8	12.2	7.10	77.08	25.24	0.55	0.210
T_9	12.3	6.02	73.50	19.25	0.50	0.182
SEd	1.2	0.61	7.31	2.22	0.05	0.018
CD (p=0.05)	NS	1.30	NS	4.52	NS	0.038

Table 5. Influence of sustainable nutrient management practices on cooking characteristics of milled rice

Treatments	Cooking time (minutes)	Volume expansion ratio	Water absorption ratio	Linear elongation ratio	Breadth wise expansion ratio	Length breadth ratio after cooking (mm)
T_1	18.16	3.24	4.68	1.87	1.21	4.10
T_2	18.17	2.86	4.24	1.74	1.21	4.03
T_3	18.46	2.92	4.27	1.75	1.22	4.02
T_4	18.18	2.55	4.14	1.74	1.21	4.04
T_5	18.16	2.52	4.12	1.74	1.21	4.03
T_6	18.17	2.98	4.28	1.74	1.21	4.03
T_7	18.20	3.00	4.33	1.77	1.24	4.03
T_8	18.22	2.96	4.30	1.76	1.21	4.03
T_9	18.23	2.48	4.11	1.70	1.19	3.99
SEd	1.73	0.26	0.40	0.17	0.12	0.38
CD (p=0.05)	NS	0.54	NS	NS	NS	NS

4. CONCLUSION

From the experimental results, it can be concluded that application of 100 per cent N through dhaincha and balance P and K through inorganic fertilizers is recommended for getting maximum quality characteristics of rice including physical parameters , chemical parameters along with cooking quality followed by application of 100 per cent NPK through inorganic fertilizers + 6.25t dhaincha. These eco-friendly management practices seem to be better quality characteristics to the rice growers of Tamil Nadu.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX I

Weather conditions prevailed during the cropping period (August – December, 2019)

Standard week	Date	Temperatur (◦C)		Relative humidity (%)		Rainfall (mm)	Sunshine (hrs)	Evaporation (mm day^{-1})
		Max	Min	07 22 hrs.	14 22 hrs.			
August								
31	30-5	29.6	23.2	78.1	63.1	22.8	3.9	5.7
32	6-12	30.1	22.8	84.1	58.7	-	3.4	5.2
33	13-19	30.1	22.7	91.0	57.9	46.1	7.4	4.9
34	20-26	31.2	23.3	85.7	56.1	6.8	7.3	5.9
35	27-2	29.7	23.7	67.6	63.0	4.8	4.0	6.3
September								
36	3-9	29.7	23.1	81.3	54.0	-	6.2	6.6
37	10-16	30.8	22.0	85.0	52.4	3.0	8.4	5.8
38	17-23	32.3	22.3	85.9	49.9	7.6	8.1	6.4
39	24-30	32.7	22.3	90.7	61.0	75.9	7.0	5.6
October								
40	1-7	32.3	23.0	92.1	59.3	74.6	7.2	4.0
41	8-14	31.7	22.9	92.1	62.0	36.6	6.0	4.0
42	15-21	31.0	22.6	94.0	80.9	154.7	3.1	3.5
43	22-28	28.6	22.3	93.7	70.3	67.2	4.9	3.1
44	29-4	29.0	22.4	92.3	66.4	25.6	3.1	2.8
November								
45	5-11	31.3	22.0	92.9	51.3	-	6.0	3.4
46	12-18	29.8	22.1	89.1	61.6	2.2	5.8	4.0
47	19-25	29.1	22.0	89.3	56.7	1.2	3.5	4.2
48	26-2	27.6	20.5	84.1	55.4	0.2	1.5	3.0
December								
49	3-9	29.3	19.2	90.0	52.3	-	6.5	4.0
50	10-16	28.7	22.5	90.6	65.5	10.6	4.1	3.0
51	17-23	28.3	21.5	91.8	56.0	1.9	3.8	3.1
52	24-25	29.0	20.7	92.6	49.6	-	3.5	3.4

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