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Influence of polymer seed coating, Nano nutrient and packaging materials on storability of hybrid rice KRH 4

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Abstract
A storage experiment was conducted to understand the effect of polymer, containers and seed treatment on storability of hybrid rice KRH 4. The observations were recorded on characters *viz,* germination (cm), root length (cm), shoot length (cm), and electrical conductivity (µS ppm^{-1})of seed leachate after 2 months of duration for 16 months of storage. The results show that the treatments of seed stored in supergrain bag for 16 months recorded significant higher percentage of germination (85 %), root length (22.4 cm), shoot length(12.9 cm), electrical conductivity (83.10 µS ppm^{-1}**)** and Total dehydrogenase activity(0.83 A_{480}) as compared to other treated seeds were stored in jute bag. Germination percentage decreased with the period of ageing. Seeds are stored in plastic bags were affected due to storage but the effects were more pronounced in the plastic bags as compared to jute bags. These result indicates that the seeds packed in supergrain bag were good in seed quality characters.

Keywords: Polymer seed coating, Nano nutrient, packaging materials, storability, hybrid rice KRH 4

Introduction
The germination of paddy varieties in storage does not suffer much as compared to other cereals (Paderes, *et al.*, 1997) [10]. However, paddy seed stored for long-term is invariably exposed to climatic adversities *e.g.* extreme summer, winter and monsoons and requires a great deal of effort to safeguard it. There is hardly any recommendation available to maintain seed quality during storage. Seed vigour is an important aspect of seed quality, which controls field stand, establishment ability and performance. The problems associated with establishing Vigorously growing seedlings are often related to poor seed quality. High quality seeds have the capacity to provide vigorous seedlings over a wide range of environments. Deterioration of high quality seed, can render seed worthless for planting although its germination per cent remains relatively high (Christiansen and Presley, 1967) [2]. The seed is said to be in storage at all the stages between harvest to sowing. These stages are considered actually part of storage process.
The extent of storability influenced by type of packaging material. In general seed stored in moisture impervious sealed containers provide suitable environment for storage, often protection against contamination and also acts as a barrier against the escape of seed treatment chemicals than in moisture pervious containers. The package which is moisture proof or moisture resistant would be more valuable in prolonging germination and vigour (Harrington 1973) [6]. Hence, the present study was carried out to study the influence of packaging material on germination and seed vigour characters of rice (*Oryza sativa* L.) during storage. Seed storage is an essential segment of seed industry. During storage, viability and vigour of the seeds is regulated by many physico-chemical factors like moisture content of the seed. atmospheric humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure and packaging materials. As the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature. To combat these factors, it is better to store the seeds in moisture vapour proof containers like polythene bag, aluminium foil, tin or any sealed container to maintain the quality for longer period. Indiscriminate use of chemical and their residual toxicity adversely affect the seed quality. Many of synthetic chemicals look effective but they are not readily degradable physically or biologically which yield more toxic residues.
There is an increasing awareness of saving both time and expense that are realized by using suitable moisture-barrier containers for storing valuable breeding stocks. However, seeds are carried over to the second planting season require drying and packing in moisture barrier

containers to prevent loss of viability and vigour (Justice and Bass, 1979) [7]. Modern packaging uses dozens of methods and materials to keep seeds at their original quality from the time they are processed to the time they are planted.

Materials and methods

Seed source: A freshly harvested seeds of hybrid rice KRH 4 were procured from Zonal Agricultural Research Station, V. C Farm, Mandya (Karnataka). Insect and disease free seeds were procured, under sized and damaged seeds were sieved, handpicked and cleaned and graded to uniform size. Initial seed quality parameters were recorded.

Seed treatment

Seeds were cleaned, dried to desired level of moisture and the seeds were treated with the nanonutrient and synthetic polymer uniformly onto to seeds by using seed manual treater. Then the poly-coated seeds were shade dried and were packed in jute bag (C_1), normal polythene bag (700 gauges) (C_2), vacuum polythene bag (C_3), supergrain bag (C_4) and stored under ambient condition in the Department of Seed Science and Technology, Gandhi Krishi Vignana Kendra, Bengaluru for the period of 16 months

Storage procedure

The processed hybrid rice KRH 4 seeds were dried to moisture content of 10 percent and treated with 5 ml of nano nutrient and 5 ml of polymers per kg of seeds before packing in jute bag (C_1), polythene bag (700 gauge) (C_2), vaccum polythene bag (C_3) and super grain bag (C_4).Packaging materials are Control (P_0), Incotech polymer-Yellow (P_1) and Incotech polymer-Pink(P_2).Nano nutrient treatments (T) are Control (T_1), Nualgi (1.5 ml/kg) (T_2), Nualgi (2.0 ml/kg) (T_3), Nualgi (2.5 ml/kg) (T_4), Nualgi (3.0 ml/kg) (T_5), (T_6) Nualgi (3.5 ml/kg).Three hundred thirty six sub-samples weighing 50 grams of each were drawn randomly from the main seed lot procured. Each packaging material (jute bag, polythene-700 gauge), vaccum packing and super grain package contains set of forty eight sub-samples for one month observation. The sub-samples were made in advance to avoid sampling errors. The study on different packaging materials effect on seed longevity of hybrid rice KRH 4 was initiated from second week of November 2015 and continued up to the second week of January 2017. The seed quality parameters were analysis using seeds of sub-samples of each packaging material were obtained bi-monthly bimonthly interval of storage period and tested for in the Department of Seed Science and Technology, GKVK, University of Agricultural Sciences, Bengaluru.

Results and discussions

Germination

The effect of seed treatment on germination were observed throughout storage period (Table 1). Among the polymer coating incotech polymer-pink (P_2) recorded significantly higher germination (%) compared to untreated seeds. Higher germination (%) was recorded with seeds stored in supergrain bag at the end of storage period (85.50 %) and minimum seed germination (%) was recorded throughout the storage period with control (T_1) which recorded a germination percentage of 79.50 at the end of 16t^{h} month of storage. Whereas nano nutrient show non-significant difference among the treatment. This decrease in seed quality during storage may be attributed to ageing effects, leading to depletion of food reserves and decline in synthetic activity of the embryo apart from death of seeds because of fungal invasion (Gupta *et al*., 1993) [5]. However, the average germination was above the minimum seed certification standards (70.00 %) even after 6th months of storage.

The polymer keeps the seed intact, as it acts as binding material and covers the minor cracks and aberrations on the seed coat thus blocking the fungal invasion. It may also act as a physical barrier which reduces leaching of inhibitors from seed coverings and restrict oxygen movement and thus reducing the respiration of embryo there by reducing the ageing effect on seeds (Duan and Burris, 1997) [4]. The polymer also prevents moisture content fluctuations during storage (West, *et al*., 1985) [13].

Shoot length

The results on shoot length as influenced by polymer coat, packaging materials and seed treatments in hybrid rice KRH4 during storage. (Table 2) There was a gradual decrease in shoot length with the advancement of storage period. Significantly highest shoot length (13.37 cm) was recorded in polymer- pink (P_2). Whereas, lowest shoot length recorded in control (P_0) (12.78 cm).Among packaging materials highest shoot length (14.59 cm) was recorded in super grain bag (C_4) followed by polythene bag (C_2) (14.15 cm) as compared to jute bag (C_1) (13.25 cm). Similarly super grain bag (C_4) had shown highest shoot length throughout the storage periods. At the end of sixteen months of storage period super grain bag (C_4) recorded highest shoot length (12.91 cm) followed by polythene bag (C_2) (10.00 cm) and lowest was recorded in jute bag (C_1) (3.93 cm).

Root length

There was a gradual increase in root length with the advancement of storage period in both incotech polymer-yellow (P_1) and incotech polymer-pink (P_2). Significantly highest root length (22.92 cm) was recorded in polymer-pink (P_2). Whereas, lowest root length recorded in control (P_0) (22.71 cm) after two months of storage period. Among packaging materials at the end of sixteen months of storage period super grain bag (C_4) recorded highest root length (22.40 cm) followed by polythene bag (C_2)(19.76 cm) and lowest was recorded in jute bag (C_1) (14.03 cm). (Table 3)

During long-term storage, all seeds undergo aging processes leading to deterioration in seed quality. Most seed lots fail to germinate when stored for about 5-6 months in poor packaging material at even low moisture because over a period poor packaging material cant able to maintain moisture proof property due to the highest vapour pressure gradient between the seeds and external environment. In the study, seeds stored in super grain bag put forth highest root growth than their counterparts from jute bag which might be due to super gain bag maintenance low respiration rate and high mobilization efficiency. These findings are in confirmity with Tammanagouda (2002) [12] in green gram. Among seed treatments, spinosad and thiram had maintained highest root length by providing congenial conditions to seed material by preventing storage insect pest and microbial activity. Thus maintained highest root length even after 12 months of storage period.

Seed electrical conductivity

The results on electrical conductivity as influenced by polymer coat, packaging materials and seed treatments in rice hybrid KRH 4 during storage are presented in table 4 Significantly highest electrical conductivity (70.74 µS ppm^{-1}) was recorded in control (P_0)followed by incotech polymer-yellow (P_1) (69.91 µS ppm^{-1}). Whereas, lowest electrical conductivity recorded in incotechpolymer-pink (P_2) (67.81µS ppm^{-1}) after four months of storage period. Among the packaging material the electrical conductivity increased with the advancement of storage period. Lowest electrical conductivity was recorded in super grain bag (C_3) (57.17 to 83.10 µS ppm^{-1}) from second month to sixteen month of storage period followed by polythene bag (C_2) (65.23 to 131.53 µS ppm^{-1}).

Ageing greatly affect the electrolyte leakage in paddy seeds. It can be appreciated, therefore, that the deteriorated seeds that show such diversity in their final germination response may be due to the metabolic lesions affecting viability and vigour. Results demonstrated that the highest electrical conductivity of paddy seed is related to its membrane disintegration and finally loss of viability. Similar results were also observed by Osborne (1980) [9] and Mumtaz *et al*. (2004) [8] in case of rice seed.

Total dehydrogenase (TDH) activity (A_{480})

The data pertaining to TDH as influenced by polymer coat, packaging materials and seed treatments and their interaction in hybrid rice KRH 4 during storage are presented in table 5 There was a gradual increase in TDH with the advancement of storage period in both incotech polymer-yellow (P_1) and incotech polymer-pink (P_2). Significantly highest TDH was recorded in polymer-pink (P_2) (0.911 A_{480}) followed by incotech polymer-yellow (P_1) (0.903 A_{480}). Whereas, lowest TDH recorded in control (P_0) (0.894 A_{480}) after two months of storage period. Among packaging materials. Highest TDH activity was recorded in super grain bag (C_4) (0.943 to 0.830 A_{480}) from second month to sixteen month of storage period followed by polythene bag (C_2) (0.926 to 0.636 A_{480}) and lowest TDH activity was noticed in jute bag (C_1) (0.892 to 0.234 A_{480}).

Total dehydrogenase enzyme (TDH) is one of the important enzymes essential for protein synthesis and energy production during germination. These finding are in concurrence with the results of Bailly *et al*., (1997) [1], Pallavi *et al*., (2003) [11] in sunflower. Declined TDH activity it could be due to enzymes undergoes compositional changes by losing or gaining certain functional groups, by oxidation of sulf-hydral groups or by conversion of amino acids within the protein structure. The enzymes may undergo configurational changes such as partial folding or unfolding of ultrastructrure, condensation to form polymers and degradation to sub units. Copeland and McDonald (1995) [3] also reported that continual accumulation of free fatty acids culminated in a reduction of cellular pH and was detrimental to normal cellular metabolism. Furthermore, it denatures enzymes resulting in their loss of activity.

Table 1: Influence of polymer coat, nanonutrient and packaging materials on seed germination per cent of hybrid rice (KRH 4) during storage

Treatment details	Germination (%)							
	Storage period (From November 2015 to February 2017)							
	2	4	6	8	10	12	14	16
Polymers coat (P)								
P_0 : Control	88 (63)	86 (60)	84 (58)	82 (56)	79(53)	76(50)	74(48)	71(46)
P_1 : Incotech polymer-Yellow	88(63)	86(60)	84(58)	82(57)	80(63)	77(51)	75(49)	73(48)
P_2 : Incotech polymer-Pink	89(63)	87(61)	85(59)	83(57)	81(55)	78(52)	77(51)	75(49)
S. Em±	0.53	0.56	0.67	0.82	0.64	0.49	0.53	0.42
CD (P=0.05)	NS	NS	1.88	2.30	1.78	1.36	1.50	1.17
Packaging materials (C)								
C_1 : Jute bag	87(61)	84(57)	81(54)	77(51)	73(47)	68(53)	64(40)	61(37)
C_2 : Polythene bag (700 guage)	89(63)	87(61)	86(60)	84(58)	82(56)	80(53)	79(52)	77(51)
C_3 : Vacuum polythene bag	88(62)	86(59)	83(57)	81(54)	77(51)	74(48)	72(46)	69(44)
C_4 : Super grain bag	90(64)	89(63)	88(63)	88(63)	87(61)	86(60)	86(59)	85(58)
S. Em±	0.62	0.65	0.78	0.95	0.73	0.56	0.62	0.48
CD (P=0.05)	1.73	1.81	2.17	2.66	2.05	1.57	1.73	1.35
Nano nutrient treatments (T)								
T_1 : Control	88(62)	86(60)	83(57)	81(55)	78(52)	74(49)	72(47)	70(45)
T_2 : Nualgi (1.5 ml/kg)	88(63)	86(60)	84(58)	82(56)	79(52)	75(50)	73(48)	71(46)
T_3 : Nualgi (2.0 ml/kg)	89(63)	87(61)	86(60)	84(58)	82(56)	79(53)	78(52)	76(50)
T_4 : Nualgi (2.5 ml/kg)	89(63)	87(61)	85(59)	83(58)	81(55)	79(52)	77(51)	75(49)
T_5 : Nualgi (3.0 ml/kg)	89(63)	87(61)	85(59)	83(57)	80(54)	78(52)	76(50)	74(48)
T_6 : Nualgi (3.5 ml/kg)	88(63)	86(60)	84(58)	82(56)	79(53)	77(51)	75(49)	72(47)
S. Em±	0.76	0.79	0.95	1.16	0.90	0.69	0.76	0.59
CD (P=0.05)	NS	NS	NS	NS	2.51	1.93	2.11	1.65
CV (%)	5.9	6.3	7.8	9.7	7.8	6.1	7.0	5.6

Table 2: Influence of polymer coat, nanonutrient and packaging material on root length of hybrid rice (KRH 4) during storage

Treatment details	Root length (cm)							
	Storage period (From November 2015 to February 2017)							
	2	4	6	8	10	12	14	16
Polymers coat (P)								
P_0 : Control	22.71	21.47	20.33	19.47	18.50	18.30	17.81	17.70
P_1 : Incotech polymer-Yellow	22.79	21.52	20.43	19.65	18.76	18.59	18.15	18.07
P_2 : Incotech polymer-Pink	22.92	21.89	20.94	20.37	19.64	19.50	19.13	19.06
S. Em±	0.053	0.141	0.184	0.136	0.146	0.148	0.171	0.160
CD (P=0.05)	NS	0.393	0.514	0.380	0.408	0.413	0.479	0.446
Packaging materials (C)								
C_1 : Jute bag	21.74	19.78	17.96	16.70	15.21	14.93	14.19	14.03
C_2 : Polythene bag (700 guage)	23.17	22.30	21.50	20.94	20.28	20.16	19.83	19.76
C_3 : Vacuum polythene bag	22.46	21.04	19.73	18.82	17.75	17.55	17.01	16.90
C_4 : Super grain bag	23.86	23.40	23.08	22.86	22.61	22.56	22.43	22.40
S. Em±	0.062	0.162	0.212	0.157	0.169	0.171	0.198	0.184
CD (P=0.05)	0.173	0.454	0.594	0.439	0.472	0.477	0.553	0.515
Nano nutrient treatments (T)								
T_1 : Control	22.52	21.10	19.83	18.95	17.91	17.71	17.20	17.09
T_2 : Nualgi (1.5 ml/kg)	22.63	21.31	20.13	19.31	18.34	18.16	17.68	17.57
T_3 : Nualgi (2.0 ml/kg)	23.08	22.13	21.27	20.67	19.96	19.83	19.48	19.40
T_4 : Nualgi (2.5 ml/kg)	22.98	21.95	21.01	20.35	19.59	19.44	19.06	18.98
T_5 : Nualgi (3.0 ml/kg)	22.87	21.75	20.74	20.03	19.20	19.05	18.63	18.55
T_6 : Nualgi (3.5 ml/kg)	22.75	21.53	20.43	19.67	18.77	18.60	18.15	18.06
S. Em±	0.076	0.199	0.260	0.192	0.207	0.209	0.242	0.226
CD (P=0.05)	0.211	0.556	0.727	0.538	0.578	0.584	0.678	0.631
CV (%)	2.30	6.30	8.70	6.70	7.50	7.60	9.10	8.60

Table 3: Influence of polymer coat, nanonutrient and packaging material on shoot length of hybrid rice (KRH 4) during storage

Treatment details	Shoot length (cm)							
	Storage period (From November 2015 to February 2017)							
	2	4	6	8	10	12	14	16
Polymers coat (P)								
P_0 : Control	13.80	12.78	11.82	10.64	9.65	8.80	7.94	7.54
P_1 : Incotech polymer-Yellow	13.95	13.02	12.13	11.10	10.21	9.42	8.73	8.39
P_2 : Incotech polymer-Pink	14.03	13.37	12.62	11.81	11.07	10.33	9.71	9.42
S. Em±	0.122	0.111	0.067	0.075	0.064	0.049	0.056	0.049
CD (P=0.05)	NS	0.310	0.188	0.209	0.178	0.136	0.156	0.137
Packaging materials (C)								
C_1 : Jute bag	13.25	11.77	10.32	8.59	7.09	5.73	4.50	3.93
C_2 : Polythene bag (700 guage)	14.15	13.50	12.83	12.07	11.40	10.80	10.26	10.00
C_3 : Vacuum polythene bag	13.70	12.63	11.57	10.33	9.25	8.27	7.38	6.97
C_4 : Super grain bag	14.59	14.34	14.05	13.75	13.49	13.26	13.05	12.91
S. Em±	0.141	0.128	0.078	0.086	0.073	0.056	0.064	0.057
CD (P=0.05)	0.394	0.358	0.217	0.241	0.205	0.157	0.180	0.158
Nano nutrient treatments (T)								
T_1 : Control	13.74	12.70	11.68	10.47	9.43	8.48	7.62	7.22
T_2 : Nualgi (1.5 ml/kg)	13.81	12.85	11.89	10.76	9.79	8.90	8.10	7.73
T_3 : Nualgi (2.0 ml/kg)	14.10	13.40	12.69	11.87	11.16	10.51	9.93	9.66
T_4 : Nualgi (2.5 ml/kg)	14.03	13.27	12.49	11.60	10.83	10.13	9.49	9.19
T_5 : Nualgi (3.0 ml/kg)	13.96	13.14	12.31	11.34	10.51	9.75	9.06	8.74
T_6 : Nualgi (3.5 ml/kg)	13.89	12.99	12.10	11.05	10.15	9.32	8.58	8.18
S. Em±	0.173	0.157	0.095	0.106	0.090	0.069	0.079	0.069
CD (P=0.05)	NS	NS	0.266	0.295	0.251	0.193	0.220	0.194
CV (%)	8.6	8.2	5.3	6.4	5.9	4.8	6.2	5.7

Table 4: Influence of polymer coat, nanonutrient and packaging material on electrical conductivity of hybrid rice (KRH 4) during storage

Treatment details	Electrical conductivity (µS ppm^{-1})							
	Storage period (From November 2015 to February 2017)							
	2	4	6	8	10	12	14	16
Polymers coat (P)								
P_0 : Control	64.31	70.74	101.13	46.22	80.93	118.45	154.41	183.56
P_1 : Incotech polymer-Yellow	63.68	69.91	96.53	44.73	72.06	104.86	135.45	158.87
P_2 : Incotech polymer-Pink	62.91	67.81	92.52	53.22	73.22	97.50	117.40	128.85
S. Em±	0.23	0.22	0.22	0.20	0.32	0.49	0.53	0.42
CD (P=0.05)	NS	0.62	0.61	0.57	0.91	1.36	1.50	1.17
Packaging Materials (C)								
C_1 : Jute bag	71.92	81.95	128.60	45.25	92.08	146.08	195.44	231.98
C_2 : Polythene bag (700 guage)	60.80	65.23	85.85	49.02	69.71	93.57	115.38	131.53
C_3 : Vacuum polythene bag	66.36	73.59	107.23	47.13	80.90	119.83	155.41	181.76
C_4 : Super grain bag	55.44	57.17	65.22	50.83	58.92	68.25	76.78	83.10
S. Em±	0.27	0.26	0.25	0.24	0.37	0.56	0.62	0.48
CD (P=0.05)	NS	0.72	0.71	0.66	1.05	1.57	1.73	1.35
Nano Nutrient Treatments (T)								
T_1 : Control	65.90	72.90	105.45	47.29	79.97	117.64	152.08	177.57
T_2 : Nualgi (1.5 ml/kg)	64.97	71.50	101.88	47.60	78.10	113.26	145.40	169.20
T_3 : Nualgi (2.0 ml/kg)	61.47	66.23	88.40	48.78	71.05	96.72	120.19	137.58
T_4 : Nualgi (2.5 ml/kg)	62.29	67.46	91.55	48.51	72.69	100.57	126.06	144.92
T_5 : Nualgi (3.0 ml/kg)	63.12	68.72	94.76	48.23	74.37	104.51	132.06	152.46
T_6 : Nualgi (3.5 ml/kg)	64.05	70.11	98.32	47.92	76.24	108.89	138.73	160.83
S. Em±	0.33	0.31	0.31	0.29	0.46	0.69	0.76	0.59
CD (P=0.05)	NS	NS	NS	0.81	1.28	1.93	2.11	1.65
CV (%)	3.6	3.2	2.3	4.1	4.4	4.7	3.9	2.6

Table 5: Influence of polymer coat, nanonutrient and packaging material on total dehydrogenase (TDH) activity of hybrid rice (KRH 4) during storage

Treatment details	TDH activity (A_{480})							
	Storage period (From November 2015 to February 2017)							
	2	4	6	8	10	12	14	16
Polymers coat (P)								
P_0 : Control	0.934	0.913	0.894	0.788	0.689	0.610	0.507	0.473
P_1 : Incotech polymer-Yellow	0.938	0.918	0.903	0.808	0.720	0.658	0.561	0.535
P_2 : Incotech polymer-Pink	0.940	0.923	0.911	0.831	0.750	0.698	0.617	0.593
S. Em±	0.005	0.004	0.004	0.007	0.004	0.005	0.005	0.003
CD (P=0.05)	NS	NS	0.010	0.019	0.012	0.014	0.013	0.008
Packaging materials (C)								
C_1 : Jute bag	0.925	0.892	0.866	0.706	0.551	0.442	0.282	0.234
C_2 : Polythene bag (700 guage)	0.941	0.926	0.915	0.844	0.777	0.728	0.657	0.636
C_3 : Vacuum polythene bag	0.933	0.909	0.890	0.775	0.664	0.585	0.469	0.435
C_4 : Super grain bag	0.949	0.943	0.939	0.911	0.886	0.866	0.838	0.830
S. Em±	0.006	0.005	0.004	0.008	0.005	0.006	0.005	0.003
CD (P=0.05)	NS	0.013	0.012	0.022	0.014	0.016	0.015	0.010
Nano nutrient treatments (T)								
T_1 : Control	0.934	0.911	0.893	0.781	0.674	0.597	0.485	0.452
T_2 : Nualgi (1.5 ml/kg)	0.935	0.913	0.897	0.793	0.692	0.621	0.516	0.485
T_3 : Nualgi (2.0 ml/kg)	0.940	0.924	0.912	0.836	0.764	0.711	0.635	0.612
T_4 : Nualgi (2.5 ml/kg)	0.939	0.922	0.908	0.826	0.747	0.690	0.607	0.582
T_5 : Nualgi (3.0 ml/kg)	0.938	0.919	0.905	0.816	0.730	0.668	0.579	0.552
T_6 : Nualgi (3.5 ml/kg)	0.937	0.916	0.901	0.804	0.711	0.645	0.548	0.519
S. Em±	0.008	0.006	0.005	0.010	0.006	0.007	0.007	0.004
CD (P=0.05)	NS	0.017	0.027	0.027	0.017	0.019	0.012	0.012
CV (%)	5.6	4.4	4.0	8.0	5.9	7.0	8.0	5.5

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