IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Impact Of Biofertilizers On Growth And Yield Of Selected Maize Varieties Growing In Vizianagaram District Of Andhra Pradesh

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Abstract

Maize is a staple food grain and third important cereal crop in India after rice and wheat that grows in a wide range of environments ranges from a semi-arid region to humid regions. India ranks about 4th position in the world by area and 7th in production. Andhra Pradesh is one of the largest producers of maize in India. According to the data collected between 2021-2022 maize in Andhra Pradesh was cultivated in an area of 3.42 lakh ha of yield and a productivity of 20.49 lakh tonnes and 5991 kg/ha respectively contributing about 6.09 per cent to total country's production. Vizianagaram district is located at the north eastern region where maize productionof Andhra Pradesh that ranks 4th place in the state with an area of cultivation about 41 hectares with a yield of 3797 Kg/ha. The yield in kharif is more when compared to rabi. The production varies with use of different varieties. Biofertilizers are the natural products obtained from microorganisms as a result of decomposing organic substances and help in overall growth and development of the plant. The present study discusses the use of biofertilizers and their effects on growth and yield of maize varietiesof both kharif and rabi. The DHM103 and DHM107are taken as kharif varieties and PUSA hybrid-1 and Ganga II are taken for rabi season from Vizianagaram district of Andhra Pradesh.

Introduction

Zea mays(maize) is globally called as the queen of cereals for its genetic yield potential than other cereal crop plants. It is cultivated in 166 countries among the world in tropical, sub-tropical, and temperate regions ranging various diversified soil types, climatic conditions and agricultural practices. According to FAOSTAT 2023, the total maize production is about 1210 m tonnes and a productivity of 5880 kg/ha across the world.United States stands first in maize production globally by occupying 32 percent of the total world maize production and acts as a key factor by driving the US economy. India produced about 33.62 million tonnes of maize in an area of 10.04 m hectares including both kharif and rabi in 2022. (agricoop.nic).About 82 percent of the cultivated land is predominantly occupied by maize in kharif season and stands in about 10 percent of the total maize production however more than three fourth of the total maize production in India is from

Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Karnataka and Uttar Pradesh.In Andhra Pradesh the total maize production in 2023 is about 20.69 lakh tonnes in an area of 3.45 lakh hectares.

In India, maize is a staple food grain produced more after rice and wheat that grows in a varied climatic conditions and diversified soil types. It acts as a source of food for mankind, fodder for animals and feed for poultry birds. The maize production in India is categorized into two zones as traditional and non-traditional areas. The traditional areas in India includes the states dependent on the production of maize for their food, for their primary need. The states include such as Bihar, Madhya Pradesh, Rajasthan and Uttar Pradeshand non-traditional areas includes Andhra Pradesh, Karnataka and Telangana for commercial purposefor feeding cattle and poultry there by emerging southern states as a major producer of maize in the country.

Maize production is dependent on various factors along with the nutrient availability to the crop. The nutrients in the soil play a key role in growth and yield of the crop where nitrogen, potassium and phosphorous acts as chief components. Nitrogen plays an important role in the growth of the plant and increase in production and crop yield. It also helps in development of high-quality protein in the seeds(Gustavo et al., 2016; Ljubica et al., 2018). Biofertilizers use in agriculture improves soil fertility thereby increasing the crop yield and acts as ecofriendly without any affect to the environment. Useful bacteria such as nitrogen fixing and phosphorous solubilizing bacteria helps in increasing the nutrient availability to the crop plants. Phosphate solubilizing bacteria show high growth rate in application of the biofertilizer inoculants on the crop field which shows high productivity and reduces the use of chemical fertilizers (Hameeda et al.,2008).

Materials and methods

Study area: Vizianagaram district is located in the northern eastern part of Andhra Pradesh in south India comprising an area of 4,122square kilometres. The district is situated in the geographical coordinates of 17-15 and 19-15’ northern latitude and 83-00 and 83-45’of eastern longitudes formed by some parts craved from Srikakulam and Visakhapatnam districts of Uttarandra. It is bounded by Srikakulam district on the East, Bay of Bengal on the South East, Orissa state on the North -West and Visakhapatnam on the West - South.

Climate

The climatic conditions in the study area experiences high humidity throughout the year with good seasonal rainfall. The maximum temperatures are recorded in the month of May with 39.6^{O} C and minimum temperatures of 17^{O} C in December. The summer season is from March to mid-June, which is followed by the South-West monsoon season that lasts up to mid-October. The post monsoon starts from the mid-October and continues up to the end of November. December to February is the season of generally fine weather with cool climate however, the climate of hills varies with plain areas in the district where hilly areas receive high rainfall and cooler than plain areas.

Soil type

The Vizianagaram district is characterized by consisting of red clay, loamy, sandy loam soil and with medium fertility. Plain area consists of alluvial type soils. The hill areasinclude crystallines (Khondalites, Charnockites and granitic gneisses) and meta sediments (Dolomites, Phyllites, Shales, and Quartzites) of Archaean and Pre-cambrian periods.

Irrigation

Ground water is the available form of irrigation and its occurrence and movement are influenced by a complex interplay of factors. The factors such as climate conditions, geological structure, depth of weathering, extent of factures, drainage pattern, topography, lithology, and inter relationship between these factors will impact the formation of ground water.

Experimental area

Randomized maize growing fields are selected for the study in Vizianagaram district of Andhra Pradesh. The soil was ploughed until it unties and mixed with compost. The field is made into plots for sowing the seeds of selected varieties. The DHM 103 and DHM 107 are taken as kharif varieties and PUSA hybrid-1 and Ganga II are taken for the rabi season. Each variety is grown as triplicates by spit plot type. Each plot was designed with 5.0 x 2.5 and seeds are sown up to a depth of 5-6 cm into the soil. The seeds are sown at a distance of 35cm each and the rows are made at a distance of 50 cm. The soil was ploughed well and compost along with Potassium sulphate (48% K_2O) fertilizer of 50 kg/ fed. was added before cultivation. Ammonium nitrate (33.5% N) fertilizer of 120kg/ fed was given in four batches The experimental field was irrigated by drip irrigation system.

Bioinoculant treatment of Seeds

The selectedvarieties are treated with bioinoculants of cyanobacteria and phosphate solubilizing bacterial liquid formulation for germination and active growth. These bioinoculants provide high nutrient supplement to the growing plant there by increasing the yield. Control is done by normal seeds.

Experimental treatments

1. Biofertilizers (cyanobacteria and phosphate solubilizing bacteria)

a. Cyanobacteria (CB)

b. Phosphate solubilizing bacteria (PSB)

c. Cyanobacteria and Phosphate solubilizing bacteria (CB+PSB)

d. Control (without biofertilizer)

2. Mineral fertilizer (Phosphate is given as Calcium superphosphate 15% P_2O_5)

P1~ 10kg P_2O_5/ ha(mineral P fertilizer)

P2~ 15 kg P_2O_5/ ha (mineral P fertilizer)

P3~ 20 kg P_2O_5/ ha (mineral P fertilizer)

P4~Control (without mineral P fertilizer)

Table 1. showing various combinations of treatments used for the study.

Treatment Code	Treatment (Biofertilizer + Mineral fertilizer)
T1	CB+10kg $P_2O_{5/ha}$
T2	CB+ 15kg $P_2O_{5/ha}$
T3	CB+ 20kg $P_2O_{5/ha}$
T4	CB+ Control
T5	PSB+10kg $P_2O_{5/ha}$
T6	PSB+15kg $P_2O_{5/ha}$
T7	PSB+20kg $P_2O_{5/ha}$
T8	PSB+ Control
T9	CB+PSB+10kg $P_2O_{5/ha}$
T10	CB+PSB+15kg $P_2O_{5/ha}$
T11	CB+PSB+20kg $P_2O_{5/ha}$
T12	CB+PSB+Control
T13	Control

Soil and water analysis

Random samples were collected in the experimental plots up to 25 cm depth and dried and ground and sieved by using a 2mm sieve mesh. Later the physicochemical properties are determined by laboratory analysis. The particle size and soluble cations such as Na + and K +, Ca 2+, Mg 2+ and anions like Cl–, HCO_3^- arein the soil are determined. Irrigation water was tested for P^H,cations and anions are studied.

Plant sample analysis

The plants in the selected plots were analysed for their yield components at a mature stage of 100 days after soaking the seed. After harvesting the corn are tested for yield values. Samples of about 5 for each variety are determined from the plots and tested for chlorophyll a and b contents in the sample leaves as described by the Moran (1982). The total amount of chlorophyll was calculated by sum of a and b (a+b).

Plants from each variety are analysed for their growth and yield parameters at harvesting stage as; height of the plant (cm), corn weight (g plant-1), corn length (cm), and grain weight per each corn (g). Dry plant weight (g), grain yield (kg fed-1) and Nconcentration was calculated determined using Kjeldal method, P concentration was determined by spectrophotometry and K concentration by flame photometer.

Statistical analysis

The statistical analysis was made according to Rienzo et al (2012). The variables mean between the different treatments selected from different varieties are compared using the LSD least significant differences (fisher LSD) using info Stat modelling software (Version SPSS 29-2022).

Results and discussion

Soil and water characterization

Soil characteristics are determined in the experimental plots at the starting of the kharif and rabi seasons in the year 2022 are listed in **Table 2.** The soil types are red clay, red loamy and sandy loam soils with a texture of about 61.24% of sand and 35.63% of silt and 2.36% of clay in sandy loamy soils. In clay soils 52.42% of sand and 29.36% of silt and 14.53% of clay are reported. In red loamy soils the percentage of distribution of sand is 58.06% and 36.92% of 4.67% of clay is determined. The soils are non-saline and soil reaction is alkaline (pH 8.30) for P^H test. The soluble cations were $Ca+^2$ with 6.52, $Mg+^2$ with 8.23, Na+ with 16.44 and K+ with 0.87 mmolc L-1 and with soluble anions with Cl- 16.63 and HCO_3- with 3.55 mmolc $L-^1$ respectively. The soluble cation Na+ was the dominant in the soil followed by $Mg+^2$, $Ca+^2$ and K+ and dominant soluble anion was Cl- followed by HCO_3^-. The organic matter (OM) content in the soil was determined in two seasons before cropping. The OM in the experimental plots were poor 0.8g $kg-^1$ and N, P, K, were 12.22, 2.85, 26.68mg $kg-^1$ respectively.

The results of laboratoryanalysisof Irrigation waterused for the experimental plots are given in table 3. It gives the water was medium in electrical conductivity and less saline, non-alkaline with a sodium absorption rate of 7.38. and contains NaCl, $CaSo_4$ and $CaCl_2$are reported. The concentration of $CaSo_4$ is high later followed by NaCl and $CaCl_2$.The water holding capacity is good and moisture was maintained during the experiments.

Growth parameters

The chlorophyll content analysis reveals the formation and increase of chlorophyll a and b due to the supplements from biofertilizers and mineral fertilizers given to the experimental plots in a serial manner. The combination of both biofertilizers and mineral phosphate were determined to have more effect on the chlorophyll formation in all varieties**.**The maximum was observed under the treatment T10 (CB+PSB+15kg $P_2O_{5/ha}$) and minimum at T8 (PSB+ Control).

Table 2. showing physicochemical properties ofsoil and available macro nutrients in the experimental plots

Soil particle size distribution (individual plot)(%)		
Sample average of plot 1	**Sample average of plot 2**	**Sample average of plot 3**
Sand - 61.24%	Sand - 52.42%	Sand - 58.06%
Silt - 35.63%	Silt - 29.36%	Silt - 36.92%
Clay - 2.36%	Clay - 14.53%	Clay - 4.67%
Texture – sandy loamy soil	Texture – clay soil	Texture – red loamy soils
Chemical properties		
Cations ($mmolcL^{-1}$)	Anions ($mmolcL^{-1}$)	Macronutrients
Ca^{2+} - 6.52	Cl^-- 16.63	N – 12.22 mg $kg-^1$
Mg^{2+} - 8.23	HCO_3^- - 3.55	P – 2.85 mg $kg-^1$
Na^+-16.44	SAR(Sodium adsorption rate)	K - 26.68mg $kg-^1$
K^+ - 0.87	7.38	P^H of water = 8.30

Table 3. Showing chemical analysis of irrigation water in experimentalarea.

Solublecations(mmolcL^{-1})				Solubleanions(mmolcL^{-1})			SAR %
Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{-2}	7.83
18.24	8.52	17.43	1.22	17.21	2.86	10.37	

According to Iwuagwu et al. (2013) reported that growing microbial inoculated maizeseedlingse x p r e s s e d asignificantincrease in the chlorophyll content of the maize plants whencomparedtocontrol.Wuetal.(2019) later found that chlorophyll content was increasedsignificantly due to the interaction of mineral phosphate and PSB+ CB treatments (T10, T11). They stated that the co-inoculated plants had higher chlorophyll content than that of either plants inoculated with single CB Strains, PSB strains, or non-inoculated plants.

In the present study the analysis of variance was pointed out that Ch a content was significant under mineral fertilizer level but very highly significant under biofertilizer. While both Ch b and Ch a+b contents were highly significant under mineral fertilizerlevelsandveryhighlysignificant under biofertilizer types. It can be concluded thatchlorophyllwascomparativelyaffectedbybiofertilizertypesmorethanbymineral P-fertilizers. It was observed that chlorophyll content under PSB treatment was higher than under CB+ PSB (T10)treatment. Generally, all examined growth parameters; plant height, corn length, corn diameter and corn weighthadshownthe increment due to the impact of biofertilizer types andmineralphosphatefertilizerapplications.The different concentrations of biofertilizersprovidedtheplantrootswithcompleteavailabilityof nutrients due to their solubilizing capacityreleasingthefixedionsandconsequently improve the vegetative plant growth.

The experimental plots are designed and the selected varieties of seeds were sown in the pattern suggested in methodology, plants were raised with the application of different treatments as mentioned below and the results of kharif season varieties are listed in the table 4. Different treatments and their results of rabi varieties are listed in the table 5. The yield parameters are recorded in each case of grain weight, grain weight per 100-gram, grain yield and straw yield for complete analysis of growth studies in each variety.

The table 4 shows the yield parameters of kharif varieties grown in 2023 under different treatments. A total of 13 treatments of different combinations were given with both mineral fertilizers and biofertilizers along with control to the crop plants in selected plots and observations are recorded. The combination of PSB+20kg $P_2O_{5/ha}$, (T7)and CB+PSB+20kg $P_2O_{5/ha}$(T11), gives maximum values and minimum values are reported in control(T13) and CB+ control(T4). Among the two selected varieties the yield and growth parameters are compared between the DHM 103 and DHM 107, major growing varieties in the study area.

The results of yield parameters in the rabi season 2023 are placed in the table 5. Out of the selected varieties PUSA- Hybrid – 1 and Ganga –II, among the two varieties PUSA hybrid – 1 shows good results in growth and yield parameters. The combination of PSB+20kg $P_2O_{5/ha}$ (T7) and CB+PSB+20kg $P_2O_{5/ha}$(T11) shows maximum growth in the plots and minimum was reported in CB+ Control(T4) and control (T13). The combination of cyanobacteria and phosphate solubilizing bacteria reported growth promoting characters and improved yield parameters when compared to control.

Table 4. Showing maizeyieldparametersinfluencedbymineralphosphatefertilizerandbiofertilizer in selected kharif varietiesin2023.

Treatments	**Code**	**Grainweight(gplant^{-1})**		**100-Grainweight(g)**		**Grainyield(Mgfed^{-1})**		**Strawyield(Mgfed^{-1})**	
		DHM 103	DHM 107	DHM 103	DHM 107	DHM 103	DHM 107	DHM 103	DHM 107
CB+10kg $P_2O_{5/ha}$	T1	118.41jk	117.48 jk	22.57 bc	23.21bc	1.97 d: f	2.47d: f	6.52fg	6.89 fg
CB+ 15kg $P_2O_{5/ha}$	T2	128.84 h:j	126.38h: j	21.92 bc	22.57bc	1.85 c :e	1.93c: e	8.19 ef	8.20ef
CB+ 20kg $P_2O_{5/ha}$	T3	144.45 d:g	146.85 d:g	25.32a:c	22.55a:c	1.93c: e	2.18 cd	8.15c: f	8.56
CB+ Control	T4	107.26k	102.37k	19.13c	17.58c	1.25f	1.42f	5.93g	6.02g
PSB+10kg $P_2O_{5/ha}$	T5	127.24jk	121.72 jk	24.32bc	24.26bc	1.79d: f	1.95d: f	7.56fg	7.24fg
PSB+15kg $P_2O_{5/ha}$	T6	134.51h:j	133.54h: j	26.14 bc	25.28bc	1.88c:e	1.74c: e	8.92ef	8.71ef
PSB+20kg $P_2O_{5/ha}$	T7	145.24d:g	144.22d: g	25.12a:c	25.14 a:c	2.02c: e	1.80c:e	8.77c: f	8.75f:c
PSB+ Control	T8	114.21k	127.18k	19.03c	16.30c	1.21f	1.13f	5.31g	5.28g
CB+PSB+10kg $P_2O_{5/ha}$	T9	138.49jk	135.02jk	25.53bc	24.96bc	1.86d:f	1.57d:f	8.97fg	8.91fg
CB+PSB+15kg $P_2O_{5/ha}$	T10	139.87h:j	137.95h:j	25.82bc	23.56bc	1.87c:e	1.94c:e	8.28ef	8.13ef
CB+PSB+20kg $P_2O_{5/ha}$	T11	147.52d:g	145.81d:g	27.64a:c	26.96a:c	2.51c:e	2.54c:e	8.27c:f	8.81c:f
CB+PSB+Control	T12	136.62k	134.46k	18.23c	17.29c	1.81f	1.57f	3.85g	3.81g
Control	T13	105.57k	106.5 k	16.87c	15.93 c	1.73f	1.84f	5.86g	5.79g
	LSD	12.01	12.01	4.26	4.26	0.32	0.32	0.77	0.77

Control = without biofertilizer, CB = cyanobacteria, PSB = phosphate solubilizing bacteria Differentlowercaseletterswithinthesamecolumnindicatesignificantdifferencesat 0.05. (LSD = least significance difference.

Table 5. showing maizeyieldparametersinfluencedbymineralphosphatefertilizer&biofertilizer in selected rabi varieties in 2023.

Treatments	Code	Grainweight(gplant^{-1})		100-Grainweight(g)		Grainyield(Mgfed^{-1})		Strawyield(Mgfed^{-1})	
		PUSA	Ganga II	PUSA	Ganga II	PUSA	Ganga II	PUSA	Ganga II
CB+10kg $P_2O_{5/ha}$	T1	115.45jk	114.34 jk	21.97 bc	23.21bc	1.47 d: f	2.51d: f	6.86 fg	6.88 fg
CB+ 15kg $P_2O_{5/ha}$	T2	128.04 h:j	125.38h: j	21.62 bc	22.16 bc	1.56 c :e	1.69 c: e	7.94 ef	8.20ef
CB+ 20kg $P_2O_{5/ha}$	T3	143.45 d:g	142.85 d:g	22.53a:c	22.84 a:c	1.83c: e	1.85 cd	7.58 c: f	8.36
CB+ Control	T4	105.21k	100.39k	18.33c	17.30c	1.32f	1.22f	5.33g	5.92g
PSB+10kg $P_2O_{5/ha}$	T5	125.55jk	119.68 jk	24.32bc	24.26bc	1.67d: f	1.68d: f	7.66fg	7.18 fg
PSB+15kg $P_2O_{5/ha}$	T6	132.29h:j	133.38h: j	25.54 bc	25.12bc	1.82 c :e	1.57c: e	8.52ef	8.64ef
PSB+20kg $P_2O_{5/ha}$	T7	145.21d:g	143.42d: g	24.92a:c	25.84 a:c	1.95c: e	1.85 c:e	8.88c: f	8.97f:c
PSB+ Control	T8	112.21k	126.39k	18.33c	16.20c	1.02f	1.04f	4.25g	4.93g
CB+PSB+10kg $P_2O_{5/ha}$	T9	136.54jk	133.50jk	25.33bc	24.69bc	1.69d:f	1.65d:f	8.49fg	8.21fg
CB+PSB+15kg $P_2O_{5/ha}$	T10	139.27h:j	135.95h:j	25.22bc	21.95bc	1.75c:e	1.74c:e	7.84ef	7.88ef
CB+PSB+20kg $P_2O_{5/ha}$	T11	146.02d:g	144.68d:g	26.54a:c	25.96a:c	2.31c:e	1.95c:e	7.91c:f	8.11c:f
CB+PSB+Control	T12	135.56k	133.84k	17.92c	16.21c	1.63f	1.25f	3.25g	3.61g
Control	T13	103.57k	106.5 k	16.18 c	15.63 c	1.03f	1.19	5.47 g	5.06

Control = without biofertilizer, CB = cyanobacteria, PSB = phosphate solubilizing bacteria

	LSD	12.01	12.01	4.26	4.26	0.32	0.32	0.77	0.77

Differentlowercaseletterswithinthesamecolumnindicatesignificantdifferencesat 0.05. (LSD = least significance difference

Table 6. showing the effect of biofertilizers and mineral phosphate on maize varieties under field conditionsin kharif season 2023 at harvest (plant dry weight).

T-code	**DHM 103**					**DHM 107**				
	Germination (%)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**Germination (%)**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**
T1	95.26	22.41	158.44	150.41	154.88	94.65	22.11	156.14	160.21	155.52
T2	95.41	22.82	159.41	151.67	155.26	95.21	22.54	157.44	160.85	157.29
T3	95.36	23.08	159.82	152.27	157.15	95.16	23.01	158.32	161.14	158.21
T4	94.51	20.45	156.82	147.53	150.40	94.61	21.21	151.83	152.28	150.47
T5	95.67	23.16	154.56	149.66	154.77	95.87	23.14	151.56	148.69	152.77
T6	96.12	23.54	157.20	149.58	156.70	96.28	23.34	152.27	150.54	156.72
T7	96.23	23.97	158.17	150.02	150.71	96.84	23.54	153.54	151.02	158.71
T8	95.75	22.13	146.38	143.81	154.39	96.21	22.16	148.33	144.81	159.39
T9	97.37	24.33	163.90	160.79	157.02	96.54	23.34	158.11	164.73	160.52
T10	97.44	25.21	164.42	161.45	160.72	96.67	24.21	160.37	165.84	162.42
T11	97.24	25.84	167.53	161.67	161.11	97.04	24.48	164.70	167.06	160.52
T12	95.86	24.27	165.42	162.28	161.58	96.29	23.23	165.22	168.00	161.21
T13	92.17	21.35	124.32	128.54	130.82	90.38	20.87	121.84	129.84	128.72

Table 7. showing the effect of biofertilizers and mineral phosphate on maize varieties under field conditions in rabi season 2023 at harvest (plant dry weight).

T-code	PUSA hybrid-1					Ganga II				
	Germination (%)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**Germination (%)**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**
T1	95.20	22.15	158.24	162.21	164.22	94.64	22.41	158.44	160.21	162.52
T2	95.81	22.54	158.84	162.84	165.82	95.21	22.82	159.41	160.85	163.29
T3	95.96	23.21	159.32	163.91	165.21	95.36	23.08	159.64	161.14	164.21
T4	95.12	20.45	154.83	154.02	152.12	94.91	20.45	156.73	152.28	154.47
T5	95.78	23.56	141.56	147.21	156.31	95.27	23.16	147.56	148.69	158.77
T6	96.02	23.84	147.28	148.25	159.32	96.02	23.54	152.28	150.54	160.72
T7	96.34	23.98	148.27	150.75	160.21	96.35	23.97	154.27	151.02	160.71
T8	95.54	22.17	142.33	142.81	152.39	95.54	22.13	147.34	144.81	145.39
T9	95.79	24.34	164.91	167.17	158.52	96.32	24.33	154.24	164.73	157.52
T10	96.47	25.11	165.37	167.54	160.51	96.82	25.21	157.51	165.84	160.51

T11	96.08	25.22	168.76	168.86	161.44	97.12	25.84	160.77	167.06	160.84
T12	95.80	24.2	165.42	168.02	162.05	95.64	24.27	164.04	168.00	161.58
T13	91.77	21.35	122.32	129.84	132.28	92.67	21.35	124.27	129.84	130.82

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