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MANAGEMENT OF WASTE BY COMPOSTING, VERMICOMPOSTING AND IT'S USE FOR IMPROVEMENT OF GROWTH, YIELD AND QUALITY OF FODDER MAIZE

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ABSTRACT

Disposal of organic waste from various sources like domestic, agriculture and industries has caused serious environmental hazards. In India, about 320 million tones of agricultural wastes are generated annually. A field *experiment was carried out in the research farm located at Shibala, Maharashtra, India to evaluate proper waste management method among different composting, vermicomposting methods and enhancement of growth, quality and yield of fodder maize by applying prepared manures. The vegetable waste and agricultural waste was used for preparation of different composts, vermicomposts. The fodder maize (Zea mays L.) was cultivated. The ten treatments were VAC, VBC, VBV, VPV, AAC, ABC, ABV, APV, NPK and control (CON) with four replicates each. Growth analysis as well as chemical analysis was carried out of maize plant for dry matter, N, P, K, Ca, water soluble reducing sugar etc. Total yield was also calculated after harvesting. The results show significance increase in growth, yield and nutrient quality of maize treated by organic manure. Vegetable waste has great potential for use as starting material for composting and vermicomposting than agricultural waste. Vermicomposting by worm bin method and composting by NADEP aerobic method gave better results. Composting and vermicomposting are appropriate technologies which convert waste to wealth.*

Keywords: Composting, fodder maize, improvement, vermicomposting, waste management.

INTRODUCTION

Management of solid waste has become one of the biggest problems all over the world. The rapid increase in the volume of waste is major aspect of the environmental crisis, result of rapid urbanization and booming population. In India, about 320 million tones of agricultural waste are generated annually (Suthar *et al*., 2005) of which weeds and vegetable wastes are in major proportion. Generally waste from the vegetable market is collected and dumped into the municipal landfills, causing a nuisance because of high biodegradability (Bouallagui *et al*., 2004). This result in loss of potentially valuable materials that can be processed as fertilizer, fuel and fodder (Baffi *et al*., 2005). Most common practices of waste processing are uncontrolled dumping which causes mainly water and soil pollution.

Environmental degradation is a major threat confronting the world and the rampant use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of carbon dioxide and contamination of water resources (Aveyard 1988). It leads to loss of soil fertility due to imbalanced use of fertilizers that has adversely impacted agricultural productivity and causes soil degradation (Wani and Lee 1992). Now there is growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection (Wani *et al*. 1995).

Disposal of organic wastes from various sources like domestic, agriculture and industries has caused serious environmental hazards and economic problems. In this regard, recycling of organic

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waste is feasible to produce useful organic manure for agricultural application. The biological treatment of these wastes is possible result into valuable nutrient source (Coker, 2006; Paraskeva and Diamadopoulos, 2006). A possible way to utilize this waste is by composting and vermicomposting biotechnology (Benifez *et al*., 1999; Mills, 2006).Composting and vermicomposting are the appropriate biotechnological techniques for the degradation, converting waste to wealth resulting in stable non toxic materials with good structure, with potentially high economic value as soil conditioner for the growth of the plants (Dhudat *et al*., 1997).

The role of earthworms in organic solid waste management was first highlighted by Darwin (1881) and later on other experiments were carried out (Bouche, 1979; Kale *et al*., 1982; Ismail, 1993, Edwards and Bohlen, 1996; Ansari, 2007). It has been demonstrated that earthworms can process household garbage, city refuse, sewage sludge and waste from paper, wood and food industries (Senapati and Dash, 1982; Ansari and Ismail, 2008). Composting and vermicomposting are the recycling technologies which improve the quality of products (Jayasankar, 1994. Selvi, 1996). Composting is done by different methods as NADEP aerobic method, Bangalore pit anaerobic method etc. while Vermicomposting is also carried by worm bin method, pit method etc. There is need to evaluate suitable method of waste management among these different methods for agricultural use. The present study was undertaken to convert agricultural and vegetable waste into value added manures by different methods and observe it's effect on growth, yield and quality of fodder maize.

MATERIAL AND METHODS

Experimental site:

The field experiment was conducted in the research farm located at Shibala, Dist.Yavatmal, India during the period from June 2009 to December 2009.

Raw material and composting Process:

The vegetable waste and agricultural waste was collected from nearby local market and agricultural farm. Agricultural wastes mainly include straw, dry leaves of crop plants, weeds while vegetable wastes include unused, rotten vegetable parts. Composting and vermicomposting of both wastes was carried out separately in different pits of size 120 x 75 x 100 cm (l x w x h). Composting was carried out by two methods as NADEP method (aerobic composting) and Bangalore pit method (anaerobic composting) of both wastes. Vermicomposting was carried out by two methods as worm bin (100 x 100 x 120 cm) method and pit method. After partial decomposition of waste in pit, main species of earthworm *Eudrilus eugeniae* Kinberg (100 individuals per pit, worm bin) were released. The process of composting and vermicomposting was followed as described by Stoffella and Kahn (2001) and Naikwade (2009). Finally, granulated, dark brown, well-fermented composts and vermicomposts were obtained. The uniformly mixed samples (100gm) of all manures were collected immediately from the pits for nutrients analyses.

Organic amendments and experimental plan:

Experiment was laid out in a randomized block design (RBD) with ten treatments as vegetable waste aerobic NADEP compost (VAC), vegetable waste anaerobic Bangalore pit compost (VBC), vegetable waste vermicompost by worm bin method (VBV), vegetable waste vermicompost by pit method (VPV), agricultural waste aerobic NADEP compost (AAC), agricultural waste anaerobic Bangalore pit compost (ABC), agricultural waste vermicompost by worm bin method (ABV), agricultural waste vermicompost by pit method (APV), chemical fertilizer (NPK) and control

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(CON) with four replicates each. Composts and vermicomposts were transferred to the experimental area and incorporated into the top of soil (15 - 20 cm) by disking. The fodder maize (*Zea mays* L.) var. 'African Tall' (Mahalaxmi) produced by Mahendra Hybrid Seeds Co. Ltd., Jalna was cultivated at a rate of 100 kg/ha. A plot with the size 9 m^2 and nine rows spaced 30 cm apart was adopted to keep the uniform population density.

Fertilizer applications and plant sampling:

The mineral fertilizers N, P_2O_5 and K_2O (120:80:40 kg/ha) were applied through urea, single super phosphate and murate of potash. Whole quantity of phosphorus (P) and potassium (K) was applied as basal dose for all the treatments except CON at the time of sowing and the two equal doses of nitrogen were applied at 42 and 75 DAS (days after sowing) to FER treatment alone in split doses. The crop was harvested at 90 DAS at 10 - 20 % flowering stage. At the time of harvest, total yield of aerial biomass of maize crop per plot was recorded. Plant samples (100gm) from each plot were randomly collected and kept in oven 80^{o}C till constant weight, Dry matter was determined and the dried samples were grinded and passed through 0.5 mm sieve to get equal size and packed in air tight polythene bags for analyses of nutrient uptake.

ANALYSIS:

Growth analyses -

The growth analysis of maize crop was noted at 90 DAS as plant height, diameter, number of leaves per plant, plant fresh weight, 4th upper leaf length, its width, weight and leaf area per plant was determined by gravimetric method (Shahane and Mungikar, 1984; Mungikar, 1986).

Chemical analyses -

The chemical analyses were done by adopting standard analytical methods. Calcium (Ca) content was analyzed by titrating the acid soluble ash solution against 0.01 N $KMnO_4$ solution using methyl red as indicator (AOAC, 1995). Nitrogen (N) was estimated by micro-Kjeldahl method after digesting the sample with Conc. H_2SO_4 (Bailey, 1967) and crude protein (CP) was then calculated by multiplying N value with 6.25 as specified by AOAC, (1995). Water soluble reducing sugars was determined by using Folin-wu tubes (Oser, 1979). The amount of phosphorus was measured following Fiske and Subba Rau (1972) as described by Oser (1979). Potassium (K) Content was determined on a flame photometer (model Mediflame- 127) as suggested by Jackson (1973).

Statistical analyses -

All the results were statistically analyzed using analysis of variance (ANOVA) test and treatments means were compared using the least significant difference (C.D., $p = 0.05$) which allowed determination of significance between different applications (Mungikar, 1997) .

RESULTS AND DISCUSSION

Analysis of Organic amendments -

Nutrient contents of all composts and vermicomposts used in experiment are given in Table 1. The dry matter was found more in agricultural waste compost and vermicompost as compared to vegetable waste manures. All contents as N, P, K, Ca, and C were high in vermicomposts as compared to composts. The range of nutrients in percentage was N (1.13-0.65), P (0.64-0.35), K (0.37-0.18), Ca (2.86-1.93) and C (27.18-20.47). The values are in accordance with Muthukumaravel, *et al*., (2008). Earlier range of P % in compost was 0.2 to 0.7 (Canet and Pomares, 1995; Warman

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and Termeer, 1996). Vegetable waste compost and vermicompost also shows high percentage of N, P, K as compared to agriculture waste compost and vermicompost. Similar results were recorded by Subler *et al* ,(1998). VBV showed highest nutrients where as ABC gave lowest nutrients. Nutrient status of vermicompost produced from the organic waste correlates with the earlier reports (Shinde *et al*., 1992).

The range of C:N ratio was 32.07 to 24.05. If the compost has too low C:N ratio, the ammonia released can be phytotoxic to plant roots (Zucconi et al., 1981a). A C:N ratio about 25–30 is optimum for most types of composts (Zucconi et al., 1981b). The vermicompost had narrower C:N ratio compared to compost (Rao and Dakhore, 1993). Ravichandran *et al* (2001) observed more NPK in the compost than that in the initial soil.

Growth Analysis (90 DAS)

During the growth analysis (90 DAS) the maximum height, diameter, no. of leaves per plant were found in the plants treated with VBV followed by other vermicompost, compost treatment while it was lowest in chemical fertilizer alone and control (Table 2). Organic manures significantly increased plant height over the control plants these results confirmed the findings of Ofosu and Leith (2009). The fresh weight of root, stem, leaves, 4^{th} upper leaf and total plant also followed analogous pattern. The length, width and leaf area of 4^{th} upper leaf was also high in all organic manure treated plants as compared to chemical fertilizer and control. Plants inoculated with EM manure recorded the highest leaf area growth, increase in diameter, increase in root, stem, leaf weight (Muthaura, 2010).

All results were significant over control. The application of different organic manures showed a significant increase in plant height and number of fruits plant of chilli (Dileep, 2005). A number of researchers have reported an increase in leaf area of plants with the application of organic manure (Rao and Shaktawat, 2001, Van Delden, 2001). Increased leaf area has implications for light interception and dry matter production to support plant growth and yield (Vargas, 2002). The significant influence on growth characters might have been due to the enhancement of uptake of nutrients favored by the addition of organic manures.

Chemical analysis of maize plant at 90 DAS

a) Chemical analysis of root:

Chemical analysis of root is given in Table 3. The dry matter percentage was in the range of 32.08-34.80. Nitrogen and crude protein was highest in VBV followed by VPV and other compost and vermicompost treatment and lowest in chemical fertilizer and control. Same pattern was observed in percentage of water soluble reducing sugar, P, K and Ca. Accumulation of dry matter and its distribution into different plant components is an important consideration in achieving desirable economic yield from crop plants (Singh and Yadav, 1989). Nitrogen, phosphorus and potassium and other nutrient elements play great physiological importance in formation of chlorophyll, nucleotides, phosphotides, alkaloids as well as in many enzymes, hormones and vitamins for optimum crop yield (Mohamed *et al*., 2008).

b) Chemical analysis of stem:

Dry matter percentage of stem was in the range of 12.16 -15.38 (Table 4). Nitrogen, crude protein, water soluble reducing sugar, P, K and Ca percentage was higher in vermicompost prepared from vegetable waste, agricultural waste as compared to compost while lowest in chemical fertilizer

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and control. Patra *et al.* (2000) proved that organic manure contains high content of nitrogen and phosphorus result in slow and sustainable availability of the nutrients which occur in various crops parts. Same results were obtained in mint by Chand *et al.* (2001). Lakshmi Bai and Vijayalakshmi (2000) have reported similar increase in NPK values on subjecting sugar factory filter press mud to vermicomposting.

c) Chemical analysis of leaves:

Details of chemical analysis of leaves are given in Table 5. Dry matter percentage was in the range of 25.35-27.73. Nitrogen, crude protein, water soluble reducing sugar, P, K and Ca percentage was higher in VBV, VPV and other vermicompost and compost treatments. Organic manures increase nutrient quality of crops (Nandi and Mandal, 1977). Same results were obtained by Minhas and Sood (1994).

Comparing with different parts of fodder maize maximum dry matter, nitrogen and crude protein was found in roots, leaves respectively. Compost and vermicompost increase the percentage of water soluble reducing sugar in total plant of fodder maize especially stem of plant resulting in more palatability of fodder for cattle. Application of organic manures thus would have helped in the plant metabolic activity in the early vigorous growth of crop plants (Anburani and Manivannan 2002).

Total yield and analysis of aerial biomass of fodder maize:

The average yield of fresh aerial biomass (kg/ha) of maize was highest (32056 kg/ha) in the plots received with VBV amendment followed in order by VPV, ABV,APV, VAC, VBC, ABC, AAC, NPK (25811 kg/ha) and lowest in CON (17556kg/ha)(Table 6). Similar pattern was observed in yield of nitrogen, crude protein, water soluble reducing sugar. On the basis of statistical analysis it has been observed that all the values of fresh weight, dry matter, nitrogen and crude protein (kg/ha), reducing sugar (kg/ha) were statistically significant over control in all the treatments. The amount of N mineralized from organic sources in the cropping season provides a major portion of the plants N needs (Ofosu and Leith, 2009). In this experiment all organic manures used nitrogen more efficiently than chemical fertilizer. Earlier there are results of increased maize yield by application of organic manure (Adekayode and Olojugba, 2010).

The results revealed that vegetable and agricultural waste can be utilized as nutrient source of crops through composting and vermicomposting. Vegetable waste has great potential for use as starting material for composting and vermicomposting than agricultural waste. Vermicompost was found excellent for increased growth, yield and nutrient quality of fodder maize than composting. The present study supports the work of Lee (1985) who found that the earthworm casts contain more nitrogen, phosphorous and calcium. Esther Rani *et al* (2007) found that the worm *Eisenia fetida* is capable of ingesting and excreting organic materials at a high rate. Vermicompost is an excellent bio-fertilizer, which has been investigated to have favorable influence on the growth and yield parameters of several crops like paddy, sugarcane, tomato, brinjal and okra (Ismail, 1997). Vermicomposting by worm bin method and composting by NADEP aerobic method gave better results. These methods provide aeration for the activity of microbes and earthworm during decomposition. Vermicompost contributes to the supply of essential micro-nutrients (Ansari and Ismail, 2001b; Ansari, 2008a) and moreover, contains growth promoting substances like auxins and cytokinins (Krishnamoorthy and Vajranbhiah, 1986). Orozco *et al.* (1996) and Benitez *et al.* (1999) reported that vermicomposts contain nutrients in forms that are taken up readily by plants.

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CONCLUSION

Composting and vermicomposting are most suitable methods of waste management of vegetable and agricultural waste converting waste to wealth. These processes are compatible with sound environmental principles of value conservation of resources and sustainable practices. Vermicomposts and composts prepared from these waste provides plant nutrients in proper amount to crop result in improvement of growth, yield and quality of fodder maize. Vermicomposting of vegetable waste by worm bin method than Bangalore pit method is strongly suggested. Such technologies in organic waste management would lead to zero waste techno farms without the organic waste being wasted and burned rather then would result in recycling and reutilization of precious organic waste bringing about bioconservation and biovitalization of natural resources. Its regular use in agriculture may results in the long term enhancement on soil productivity.

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Table 1. Analysis of different composts and vermicomposts prepared from vegetable and agriculture waste

Treatments	%						
	DM	N	P	K	Ca	C	C:N
VAC	69.32	0.81	0.45	0.32	2.64	22.36	27.60
VBC	71.82	0.77	0.39	0.26	2.35	21.42	27.82
VBV	67.30	1.13	0.64	0.37	2.86	27.18	24.05
VPV	67.74	1.08	0.58	0.35	2.83	26.10	24.17
AAC	70.59	0.69	0.37	0.20	2.05	22.13	32.07
ABC	70.92	0.65	0.35	0.18	1.90	20.47	31.49
ABV	68.55	0.97	0.57	0.24	2.13	24.85	25.62
APV	69.07	0.91	0.50	0.23	2.08	23.41	25.73

VAC- vegetable waste aerobic NADEP compost, VBC- vegetable waste anaerobic Bangalore pit compost,VBV- vegetable waste vermicompost by worm bin method,VPV - vegetable waste vermicompost by pit method, AAC- agricultural waste aerobic NADEP compost, ABC- agricultural waste anaerobic Bangalore pit compost, ABV- agricultural waste vermicompost by worm bin method, APV- agricultural waste vermicompost by pit method

Table 2. Growth analysis of maize plant (Age of plant: 90 DAS)

Treatment	Plant height (cm)	Diameter (cm)	No of leaves /plant	Plant fresh weight(g)				4th upper leaf			Leaf area (cm2)
				Root	Stem	Leaves	Total	Length (cm)	Width (cm)	Weight (g)	
VAC	230.20	1.31	10.50	8.35	193.37	55.80	257.52	76.15	5.47	5.62	410.41
VBC	227.40	1.30	11.00	11.37	183.61	53.50	248.45	74.05	5.35	5.08	406.33
VBV	238.25	1.46	11.00	18.08	205.51	58.58	282.17	83.63	5.70	7.23	524.15
VPV	233.68	1.36	10.50	15.49	194.13	53.95	263.57	76.48	6.38	6.13	432.07
AAC	229.50	1.30	10.25	12.44	170.76	44.05	227.25	76.73	5.60	5.69	415.40
ABC	219.48	1.31	10.75	10.38	169.37	50.81	230.56	71.55	5.08	6.83	395.61
ABV	231.55	1.34	11.00	15.07	189.56	55.26	259.89	81.43	7.00	7.09	534.35
APV	228.90	1.30	10.50	9.55	186.74	54.67	250.96	82.83	5.03	6.52	489.36
NPK	213.68	1.28	9.75	5.35	167.47	52.47	225.29	75.75	6.48	6.70	362.07
CON	120.75	0.96	8.50	4.16	63.54	27.45	95.15	56.53	3.13	2.11	152.08
SE	10.96	0.04	0.25	1.40	12.70	2.85	16.44	2.44	0.33	0.47	34.04

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CD	24.76	0.09	0.56	3.17	28.71	6.44	37.16	5.51	0.76	1.07	76.94

VAC- vegetable waste aerobic NADEP compost, VBC- vegetable waste anaerobic Bangalore pit compost,VBV- vegetable waste vermicompost by worm bin method,VPV - vegetable waste vermicompost by pit method, AAC- agricultural waste aerobic NADEP compost, ABC- agricultural waste anaerobic Bangalore pit compost, ABV- agricultural waste vermicompost by worm bin method, APV- agricultural waste vermicompost by pit method, NPK-Chemical fertilizer, CON-Control, SE- Standard Error, CD- Critical Difference

Table 3. Chemical analysis of root per plant of maize (Age of plant: 90 DAS)

Treatment	%						
	Dry Matter	Nitrogen	C. Protein	W.S.R.S.	P	K	Ca
VAC	32.60	0.61	3.81	1.63	0.06	0.09	0.19
VBC	34.45	0.63	3.94	1.52	0.06	0.10	0.21
VBV	32.69	0.68	4.25	1.64	0.07	0.12	0.24
VPV	33.92	0.71	4.44	1.60	0.08	0.11	0.24
AAC	34.55	0.69	4.31	1.53	0.06	0.09	0.18
ABC	32.87	0.65	4.06	1.52	0.06	0.08	0.19
ABV	33.04	0.68	4.25	1.58	0.07	0.10	0.20
APV	34.80	0.67	4.19	1.53	0.07	0.11	0.21
NPK	32.08	0.58	3.63	1.51	0.05	0.08	0.17
CON	33.73	0.51	3.19	1.42	0.05	0.07	0.15

VAC- vegetable waste aerobic NADEP compost, VBC- vegetable waste anaerobic Bangalore pit compost,VBV- vegetable waste vermicompost by worm bin method,VPV - vegetable waste vermicompost by pit method, AAC- agricultural waste aerobic NADEP compost, ABC- agricultural waste anaerobic Bangalore pit compost, ABV- agricultural waste vermicompost by worm bin method, APV- agricultural waste vermicompost by pit method, NPK-Chemical fertilizer, CON-Control, C. Protein- Crude Protein, W.S.R.S.- Water soluble reducing sugar.

Table 4. Chemical analysis of stem per plant of maize (Age of plant: 90 DAS)

Treatment	%						
	Dry Matter	Nitrogen	C. Protein	W.S.R.S.	P	K	Ca
VAC	13.55	1.12	7.00	5.31	0.11	0.63	0.17
VBC	12.82	1.08	6.75	5.63	0.11	0.55	0.20
VBV	15.21	1.23	7.69	6.11	0.13	0.72	0.22
VPV	15.38	1.19	7.44	6.05	0.12	0.71	0.19
AAC	12.47	1.05	6.56	5.07	0.10	0.58	0.18
ABC	12.20	0.96	6.00	4.98	0.11	0.53	0.16
ABV	14.29	1.07	6.69	4.91	0.12	0.68	0.20
APV	13.94	1.10	6.88	5.20	0.11	0.66	0.18
NPK	12.16	0.92	5.75	4.47	0.10	0.52	0.14
CON	12.35	0.81	5.06	4.15	0.09	0.41	0.11

Table 5. Chemical analysis of leaves per plant of maize (Age of plant: 90 DAS)

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Treatment	%					
	Dry Matter	Nitrogen	C. Protein	W.S.R.S.	P	K	Ca
VAC	25.49	2.21	13.81	3.24	0.10	0.57	0.29
VBC	25.91	2.14	13.38	3.15	0.09	0.50	0.24
VBV	27.73	2.43	15.19	3.62	0.12	0.68	0.31
VPV	27.28	2.44	15.25	3.57	0.10	0.65	0.29
AAC	25.66	2.06	12.88	3.11	0.10	0.53	0.25
ABC	26.03	2.11	13.19	3.20	0.09	0.49	0.26
ABV	26.50	2.39	14.94	3.45	0.11	0.61	0.28
APV	26.89	2.33	14.56	3.52	0.10	0.58	0.28
NPK	25.63	2.02	12.63	2.96	0.09	0.46	0.19
CON	25.35	1.69	10.56	2.55	0.08	0.35	0.14

Table 6. Analysis of total aerial biomass of maize plants (Age of crop: 90 DAS)

Treatment	Fresh Wt.	Dry matter		Nitrogen		Crude Protein		W.S.R.S.	
	Kg/ha	%	Kg/ha	%	Kg/ha	%	Kg/ha	%	Kg/ha
VAC	29811	18.67	5566	1.43	80	8.94	497	4.98	277
VBC	29167	18.45	5381	1.35	73	8.44	454	5.05	272
VBV	32056	19.52	6257	1.46	91	9.13	571	5.10	319
VPV	31489	19.13	6024	1.42	86	8.88	535	5.02	302
AAC	28344	18.25	5173	1.27	66	7.94	411	4.81	249
ABC	28556	18.10	5169	1.31	68	8.19	423	4.60	238
ABV	30633	19.21	5885	1.34	79	8.38	493	4.87	287
APV	30067	19.05	5728	1.38	79	8.63	494	4.85	278
NPK	25811	18.52	4780	1.12	54	7.00	335	4.12	197
CON	17556	18.12	3181	0.93	30	5.81	185	3.64	116
SE	1323		276		5.66		35.38		18.77
CD	2990		623		12.79		79.95		42.41