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PRECISION NUTRIENT MANAGEMENT FOR SOIL SPATIAL VARIABILITY

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Abstract

Field experiments were carried out to study the Precision nutrients management in sugarcane during 2005-06 and 2006-07 at Research and Development Farm NSSK, Krishna Nagar, Dt. Bijapur. The experiment in farmer's field extended to 2007-08 as only preliminary studies were conducted during 2005-06. Initial nutrients status of soil varied markedly from bigger sized plots in farmers field 4.0 ha (149 kg N/ha to 325 kg N/ha) to a smallest sized grid of 10 m × 10 m (140 kg N/ha to 245 kg N/ha). Large yield variations in grids of uniformity trial (82.7 t/ha - 128.2 t/ha) 45.5 t/ha and nutrients uptake by the crop ranged between 148.9 – 547.4 kg N/ha (398.5), 2.48 – 15.61 kg P/ha (13.13) and 124.8 – 434.2 kg K/ha (309.4). Sugarcane plant crop in farmers fields recorded significantly higher yield (139.7 t/ha) in relatively high nitrogen containing soils over the low soil nitrogen containing groups (119.0 t/ha). Similar observations were recorded in growth and yield parameters of sugarcane.

Key words : Sugarcane, soil fertility, Global positioning system (GPS), Geographic information system (GIS).

Introduction

The traditional approach to soil fertility management has been to treat fields as homogenous area and to calculate fertilizers, chemicals and other crop production inputs on the whole field basis. This management protocol often results in over-application of crop production inputs in some field areas and under application in others due to variations of field characteristics including soil organic carbon, soil texture, soil structure, soil nutrients, field topography and other properties. This has been reported at least 80 years back that fields are not homogenous and sampling techniques to describe field variability have been recommended (Linsley and Bauer, 1929).

Describing the spatial variability across a field was difficult until new technologies such as Global Positioning System (GPS) and Geographic Information System (GIS) were introduced. However, their effectiveness in the field of agriculture can be made use only when proper ground truth studies are carried out in detail over a period of time.

These technologies allow fields and soil sample locations to be mapped accurately and also allow complex spatial relationships between soil fertility factors to be computed. This in turn has increased interest in the use of soil sampling techniques that attempt to describe the variability in soil fertility factors within a field. Thus, precision agriculture is proven to be a valuable management tool for crop producers throughout the world, allowing for increases in profit through more efficient application of crop inputs and mapping of yield and quality variability.

Site-specific management assists growers in making precise management decisions for different cropping systems throughout the world. Site-specific management recognizes the inherent spatial variability associated with most fields under crop production (Thrikawala *et al.*, 1999).

Site specific management of zones within field on cluster basis coupled with target yield approach may further enhance the nutrient use efficiency and helps sustained yield level of crops on the whole field basis. It is some times although look tedious to workout the fertilizers for each zone/ cluster zones but helps to save lot of fertilizers by avoiding over application in areas where the nutrient availability suffices the crop demand and suggests to apply the nutrients as per the crop demand to get uniform yields over the field.

Materials and Methods

The experiment was conducted at Research and Development Farm, Nandi Sahakari Sakkare Karkhane (NSSK), Krishna Nagar, Dt : Bijapur, which lies in Northern Dry Zone (Zone-3) of Karnataka and Region

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II of Agro-Climatic Zones of India.

The site-specific nutrients management for target yield experiment was laid out in Block No. 7 of R & D farm at 16°26’ 42.8” N latitude, 75° 28’ 11.4” East longitude.

One acre area was divided into 30 equal plots of size 10 m × 10 m size and the surrounding area was planted with general sugarcane. Those 30 plots formed treatment plots. Ridges and furrows were opened at 120 cm apart, soil samples were drawn and planting of sugarcane with two eye budded setts with setts treatment with endosulfan @ 2 ml per litre and Bavistin @ 2 g per litre was done. Eight rows of sugarcane in each plot was fitted.

The average rainfall of the area is 540 mm which is distributed over a period of five to six months (June to October) with peak rainfall mainly received in the months September and October (120 mm).

The rainfall is not well assured and is unevenly distributed as a result the main source of water supply to crop is through irrigation from borewells and river lift irrigation systems. April and May are the months of mean maximum temperature ranging from 35.0°C to 43.0°C, while, December is the month of mean minimum temperature ranging from 8°C to 15°C.

During the crop growing season, the rainfall was higher by 15 per cent during 2005. However, the crop did not suffer from moisture stress as it was grown under assured irrigation source.

Soil characteristics

The soil of the experimental sites was medium deep black clay in nature and belong to Chromoustert of the order vertisol. Soil samples were drawn from 0-30 cm, 30-60 cm and 60-90 cm soil depth from the profile opened for the estimation of physical properties. The soil samples were air dried, lightly crushed and passed through two mm sieve. The initial soil available nutrients status (kg/ha) are furnished in table 1.

Uniformity trial

Sugarcane crop was raised without application of any fertilizers and organic manures. Periodic observations on growth and yield parameters were recorded. The crop was harvested during first week of February and subsequently the cultural operations were carried out to raise a good ratoon crop. Treatment plot was applied with basal applications @ 5 t/ha vermicompost to each plot and entire quantity of phosphorus through single super phosphate as per the target yield requirement for each plot was calculated and applied.

Nitrogen and potassium requirement for each plot was calculated and the quantity to be applied for each plot was divided into 6 equal parts and was applied at monthly intervals from 90 days after ratooning upto 240 days after ratooning. Crop was raised under standard crop husbandry practices by varying only the quantity of fertilizer nutrients.

The fertilizers were applied on the basis of nutrient requirement of the crop based on target yield (250 t/ha). The fertilizers required for each plot was calculated using the formulae based on the soil available nutrient status.

$$FD = NR/CF \times 100 \times T - CS / CF \times STV$$

Where,

FD = Fertilizer N or P_2O_5 or K_2O (kg/ha)

NR = Nutrient requirement of N or P_2O_5 or K_2O (kg/t)

CF = Contribution from fertilizers N or P_2O_5 or K_2O (%)

CS = Contribution from soil N or P_2O_5 or K_2O (%)

STV = Soil test value of N or P × 2.29 or K × 1.21 (kg/ha).

1. $$NR = \frac{\text{Total uptake of nutrients in treated plot (kg/ha)}}{\text{Economic yield (q/ha)}}$$

2. $$\%CS = \frac{\text{Total uptake in control plot}}{\text{STV for control plot}} \times 100$$

3. $$\%CF = \frac{\text{(Total uptake in treated plot)} - \text{(STV of soil)}}{\text{Fertilizer dose applied}} \times 100$$

4. $$\text{Nutrient supplied through soil (NSS)} = STV \times \frac{CS}{100}$$

Results and Discussion

Sugarcane yields of uniformity trial with respect to the initial soil nitrogen availability indicated that the lower available soil nitrogen grids recorded lower yields of sugarcane. While, the higher available soil nitrogen grids recorded higher yields indicating that the available soil nitrogen is being used by the crop and the quantity of available nitrogen decides the yield levels (Peter *et al.*, 2003). On the contrary few grids with higher as well as lower available soil nitrogen recorded medium yield levels of sugarcane which tried to exhibit the potentiality of the soils to mineralize the nutrient nitrogen from the total nitrogen in due course of time during the crop growth period and helped the crop to grow luxuriantly without facing any deficiency, which otherwise to say the soils have an inherent nutrient buffering capacity to suffice the nutrient needs of the crop whenever the external sources of nutrients are not applied.

Phosphorus and potassium nutrients being ample and were available in soil in their higher range could not influence much although potassium had a large range of availability among the nutrients but there was a strong buffering capacity as it was grown on medium deep black soils (table 1).

Nutrients uptake by the crops is estimated on the basis of dry matter produced. Eventually high yields should have high dry matter, it may be true in most of the crops but sugarcane crop contains more than 50 per cent of cane juice (moisture) with variations in its juice content, based on the management practices. Which otherwise

Table 1 : Soil available nutrients status before and after uniformity trial of sugarcane cropping.

Plots	Yield	Nitrogen		P_2O_5		K_2O		OC (%)	
		Before cropping	After cropping	Before cropping	After cropping	Before cropping	After cropping	Before cropping	After cropping
31	92.6	210	207.2	78.8	18.3	437	383.6	0.88	0.6
32	92.1	245	184.8	81.9	55	456	341.6	0.88	0.72
33	87.1	210	190.4	54.9	36.6	446	308	0.72	0.42
34	86.6	175	218.4	55.2	45.8	427	330.4	0.86	0.66
35	96.5	175	190.4	60.5	49.5	485	322	0.88	1.2
36	107.4	245	201.6	77.5	27.5	553	366.8	0.86	1.1
37	103.5	175	179.2	86.4	33	592	358.4	0.9	0.69
38	97.5	210	173.6	68.4	36.6	495	344.4	0.68	0.39
39	84.1	175	190.4	67.6	55	466	333.2	0.72	0.96
40	88.6	140	184.8	61.5	58.6	495	305.2	0.72	0.54
41	82.7	175	179.2	64.7	51.3	514	322	0.68	0.45
42	102.5	175	190.4	77.5	33	572	324.8	0.78	0.45
43	111.9	175	196	75.9	31.1	524	336	0.98	0.36
44	108.4	245	201.6	69.9	38.5	611	366.8	0.94	0.84
45	108.4	210	218.4	57.8	45.8	495	375.2	0.9	0.3
46	98.5	175	212.8	62.2	55	504	361.2	1.04	1.32
47	114.3	175	207.2	66.9	51.3	504	361.2	0.82	1.2
48	105.4	140	190.4	62.2	56.8	504	372.4	0.7	1.05
49	106.4	175	207.2	78	53.1	534	366.8	0.9	1.32
50	97	245	212.8	89.3	55	698	358.4	1.12	1.32
51	113.8	210	201.6	67.6	49.5	572	364	0.94	1.77
52	90.1	175	190.4	69.5	34.8	563	355.6	1.46	1.02
53	107.4	210	184.8	69.1	33	522	330.4	1.24	1.5
54	106.9	175	173.6	63.1	44	524	322	0.96	1.14
55	106.4	245	190.4	58.8	47.6	563	302.4	1.06	1.41
56	128.2	210	196	64.7	56.8	582	336	1.06	1.26
57	98.5	175	212.8	74.6	55	485	364	0.96	1.44
58	95	175	201.6	56.5	36.6	563	296.8	1.02	1.08
59	112.4	210	196	53	45.8	524	361.2	1.12	1.56
60	103.5	210	184.8	66.9	51.3	504	366.8	0.96	1.44
SD (σ)	10.48476	30.04259	12.65	9.453084	10.5	57.01264	24.11	0.173458	0.42
Correlation (r values)		0.231438	0.06	0.040646	-0.27	0.421487	0.26	0.284269	0.34
SEm±	1.914246	5.485002	2.31	1.725889	1.92	10.40904	4.4	0.031669	0.08

Table 2 : Correlation of yield with nitrogen, phosphorus and potassium uptake by the crop in uniformity trial.

Plots	Uptake (kg/ha) vs. yield (t/ha)			
	Yield	N	P	K
31	92.6	303.0	4.44	199.8
32	92.1	263.0	3.32	176.8
33	87.1	321.9	3.13	135.8
34	86.6	334.9	3.12	124.8
35	96.5	324.8	6.96	220.4
36	107.4	378.9	9.02	257.8
37	103.5	365.1	2.48	211.1
38	97.5	253.9	3.51	234.0
39	84.1	388.5	6.05	131.2
40	88.6	319.9	7.44	191.3
41	82.7	388.9	8.99	317.4
42	102.5	446.7	12.30	418.2
43	111.9	432.4	6.71	349.2
44	108.4	528.2	15.61	377.3
45	108.4	409.5	14.30	390.0
46	98.5	429.1	7.09	189.1
47	114.3	547.4	4.12	411.6
48	105.4	416.2	5.06	164.4
49	106.4	527.4	7.66	229.8
50	97.0	317.8	13.97	163.0
51	113.8	372.9	15.03	505.4
52	90.1	287.5	5.40	291.9
53	107.4	379.0	14.18	425.4
54	106.9	305.3	8.98	346.4
55	106.4	339.7	8.94	434.2
56	128.2	441.4	7.69	369.1
57	98.5	148.9	14.18	248.2
58	95.0	454.9	4.56	342.0
59	112.4	368.3	8.09	377.7
60	103.5	356.4	6.21	322.9
SD (σ)	10.48476	85.61537	4.014952	106.4358
Correlation (r values)		0.438402	0.339121	0.657581
SEm±	1.914246	15.63116	0.733027	19.43244

would not make tally with the dry matter produced and the fresh yield weight. Although, all the nutrients taken up by crop have been conserved by careful drying and by driving away the water per cent as juice also contains soluble solids.

Nitrogen uptake by the crop in uniformity trial was 441.4 kg/ha in the grid 56, which recorded the highest sugarcane yield of 128.2 t/ha. While, the grid 41 which recorded the lowest sugarcane yield 82.7 t/ha had taken up 388.9 kg nitrogen. The amount of nitrogen taken up by the crop to produce one tonne of sugarcane is 3.44 kg N in the grid which produced highest yield while it was 4.70 kg N in the grid which recorded lowest yield. The grid with highest nitrogen uptake of 547 kg/ha recorded only 114.3 t/ha of sugarcane with 4.79 kg N/tonne and the grid with lowest nitrogen uptake of 148.9 kg/ha recorded 98.5 t/ha of sugarcane with 1.51 kg N/tonne although both the grids with highest as well as the lowest nitrogen uptake had the same initial nitrogen status (175 kg N/ha). With the same initial soil nitrogen status yield as well as uptake varied and the high yield plots recorded lower amounts of uptake per tonnes and vice-versa and many grids, which lie in between the highest and the

Table 3 : Correlation of yield, growth and yield attributes in uniformity trial.

Plots	Yield (t/ha) vs. growth and yield parameters (%)							
	Yield	**Clumps**	**Tillers at 150 days**	**NMC at 180 days**	**NMC at 240 days**	**NMC at harvest**	**Girth (mm)**	**Wt. of 5 canes (kg)**
31	92.6	15499	123992	116552	106495	104755	23.36	4.51
32	92.1	13124	89243	85673	81763	79675	25.49	5.82
33	87.1	13166	95453	91635	86536	83365	22.69	5.32
34	86.6	13166	79390	77802	72900	69733	27.34	5.84
35	96.5	13416	118060	112157	107152	103199	24.76	4.76
36	107.4	15624	112492	107992	100795	98957	26.83	5.51
37	103.5	14791	127202	119570	113753	110533	23.83	4.69
38	97.5	10624	72774.00	71318	68815	65518	28.85	6.78
39	84.1	11799	79525	77536	74365	71653	28.39	5.59
40	88.6	9791	59725	58850	56580	55860	29.89	6.79
41	82.7	13500	93825	90072	84725	82754	22.49	4.96
42	102.5	15624	117180	112492	109422	105229	22.33	4.81
43	111.9	15849	137569	129315	115923	110239	28.36	5.11
44	108.4	15866	145491	135310	124455	120554	27.33	4.52
45	108.4	15124	132335	125718	117815	112158	26.95	4.85
46	98.5	12691	90106	87410	84457	81574	28.65	5.96
47	114.3	15000	124500	118275	112875	108758	30.39	5.31
48	105.4	14832	133340	126135	117135	113537	26.48	4.65
49	106.4	16666	153993	145753	132573	123755	28.39	4.31
50	97.0	14124	114545	109963	103695	98965	24.95	4.87
51	113.8	15966	136030	129228	122695	118956	29.36	4.87
52	90.1	14874	109026	105755	97577	95777	24.64	4.71
53	107.4	14275	109774	103395	95338	93833	27.79	5.86
54	106.9	14874	122710	117806	112895	108985	25.90	4.96
55	106.4	16216	154700	143871	136788	128877	27.33	4.37
56	128.2	19282	134588	127858	123896	119698	23.67	5.43
57	98.5	17074	133689	124698	116495	110594	26.79	4.61
58	95.0	18550	126140	118572	111572	106752	27.78	4.54
59	112.4	16041	126724	121954	115924	108955	28.77	5.25
60	103.5	16549	154071	144826	128862.0	121628	24.33	4.36
SD (σ)	10.48	2063.46	24889.04	22448.28	20204.11	18821.03	2.31	0.66
Correlation (r-values)		0.63	0.67	0.68	0.71	0.71	0.23	-0.21
S.Em.±	1.91	376.73	4544.10	4098.48	3688.75	3436.23	0.42	0.12

lowest ranges recorded the sugarcane yield in the similar way (table 2). This purely indicates that apart from nutrient status the agronomic management practices and the environment factors (biotic and abiotic) do play a major role in good growth and development of the crop Similar observations were made by Mu-Lien Lin and Tsang-Sen Liu (2005) thus, it needs to be studied in a system approach with combination of more number of factors which influence the crop growth and yield than studying the individual component factors to avoid the ambiguity in factors that influence the yield mostly. The growth and yield attributes like number of clumps, number of tillers and number of millable canes (NMC) were directly correlated to yield which indicated that higher

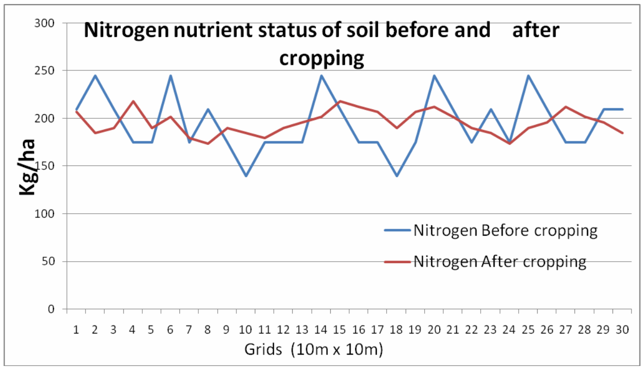

Fig. 1 :

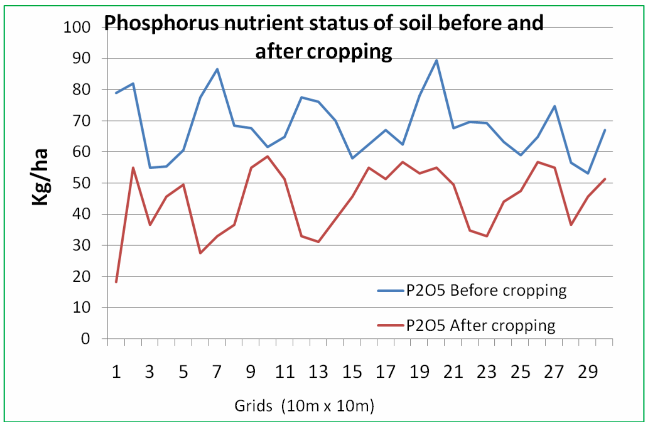

Fig. 2 :

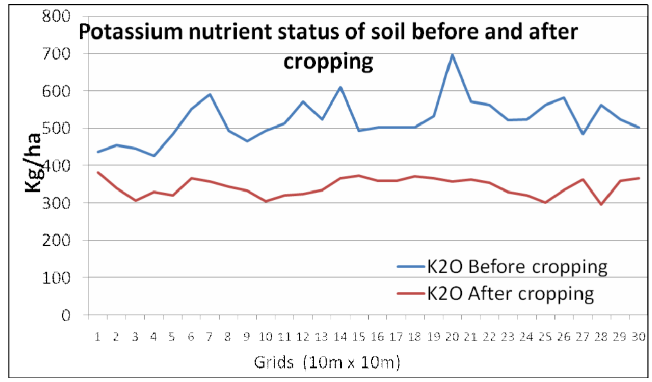

Fig. 3 :

the number of clumps and tillers, contribute to higher number of millable canes and ultimately adds to the yield. However, cane girth and weight of five canes though contribute positively to the yield but they had inverse relation with the number of millable canes. Since the space, nutrients and water availability per unit area is same for the varied number of millable canes, they express their growth and development through increase in their cane girth, moisture and total solids. Lesser the number of millable canes per unit area could provide a condition to express the canes to its potential while the higher number of millable canes restricts their expression of the characters due to insufficient resources available. Juice

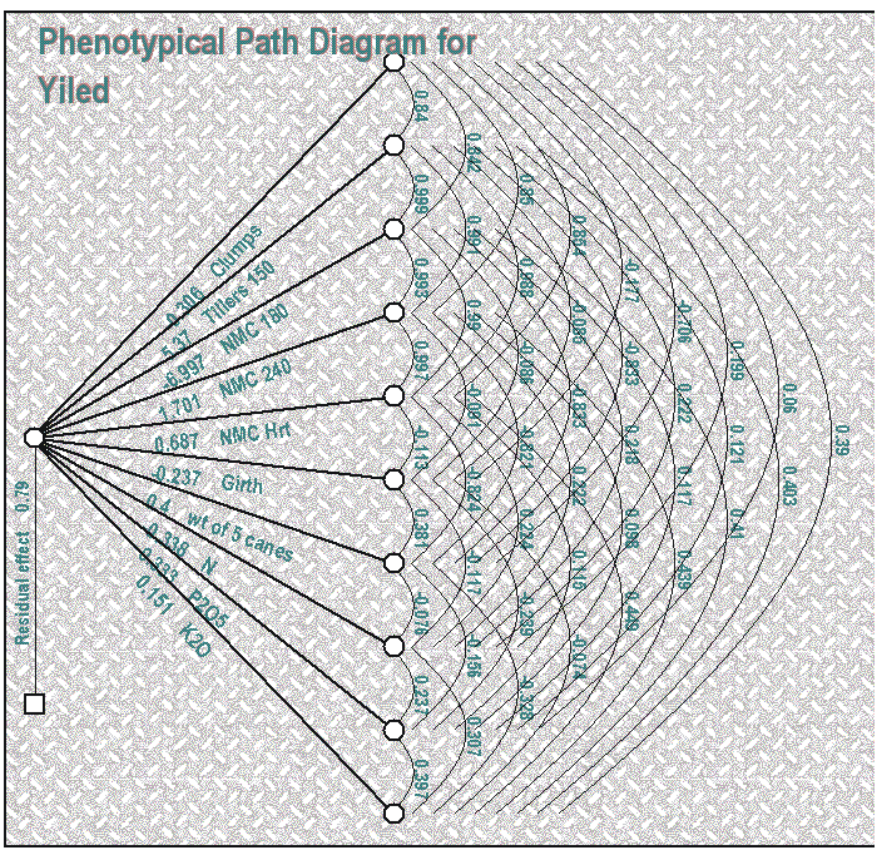

Fig. 4 : Path diagram for yield, growth and yield attributing characters and nutrient uptake in uniformity trial.

content plays major role in increasing weight to the cane apart from best agronomic practices followed in getting the quality parameters (table 3).

Plan of layout of the experiment and nutrients content (N and yield) of each plot is depicted in figure in uniformity trial (Grid size 10 m × 10 m).

55 245 106.4	56 210 128.2	57 175 98.5	58 175 95.0	59 210 112.4	60 210 103.5
49 175 106.4	50 245 97.0	51 210 113.8	52 175 90.1	53 210 107.4	54 175 106.9
43 175 111.9	44 245 108.4	45 210 108.4	46 175 98.5	47 175 114.3	48 140 105.4
37 175 103.5	38 210 97.5	39 175 84.1	40 140 88.6	41 175 82.7	42 175 102.5
31 210 92.6	32 245 92.1	33 210 87.1	34 175 86.6	35 175 96.5	36 245 107.4

Legend

N (kg/ha)	Colour		
140-160		Plot No. N (kg/ha) Yield (t/ha)	31 210 92.6
161-180			
181-200			
201-220			
221-240			
>240			

Plan of layout of the experiment and nutrients content (N and yield) of each plot is depicted in figure in SSNM target yield (Grid size 10 m × 10 m)

55 190.4 93.1	56 196.0 67.3	57 212.8 95.0	58 201.6 103.0	59 196.0 163.8	60 184.8 81.2
49 207.2 77.7	50 212.8 79.2	51 201.6 87.1	52 190.4 59.4	53 184.8 79.2	54 173.6 97.0
43 193.0 95.0	44 201.6 77.2	45 218.4 81.2	46 212.8 73.3	47 207.2 87.10	48 190.4 95.00
37 179.2 118.8	38 173.6 53.5	39 190.4 41.6	40 184.8 44.1	41 179.2 53.5	42 190.4 103.0
31 207.2 83.2	32 184.8 75.2	33 190.4 61.4	34 218.4 49.5	35 190.4 75.2	36 201.6 110.9

Legend

N (kg/ha)	Colour		
170-180		Plot No. N (kg/ha) Yield (t/ha)	31 207.2 83.2
181-190			
191-200			
201-210			
211-220			

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