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EFFECT OF IRRIGATION INTERVAL, NITROGEN LEVELS AND INTRA ROW SPACING ON GROWTH AND YIELD OF CARROT (*Daucus carota* L.) AT DADIN-KOWA, GOMBE STATE

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ABSTRACT

Field trials were conducted during 2010/2011, 2011/2012 and 2012/2013 dry seasons at the Federal College of Horticulture Research Farm, Dadin-Kowa, Gombe State to study the effect of irrigation interval, nitrogen levels and intra row spacing on growth and yield of carrot. The treatments consisted of three irrigation intervals (5, 7 and 9 days), four nitrogen rates (0, 50, 100 and 150Kg N/ha) and three intra row spacing (5, 10 and 15 cm). The treatments were combined and laid in a split-split- plot design with irrigation interval in the main plot, nitrogen levels in sub-plots while intra row spacing were assigned to the sub-sub-plots. The treatments were replicated three times in each season. The data collected were subjected to analysis of variance. Means were separated using Duncan's Multiple Range Test (DMRT). The results revealed that the application of water at every 5-days interval produced statistically taller plants, more leaves/ plant; longer leaf length, higher fresh weight of root, higher root length, higher root diameter and higher root yield in all the three seasons of study. The results also revealed that increasing levels of nitrogen from 0 to 150 Kg N/ha significantly increased the growth parameters and yield components of the crop. Similarly, increasing intra row spacing from 5 to 15cm produced significant increase in all growth characters as well as yields components at all the stages of sampling in all the three seasons of study. There was significant interaction between nitrogen application and spacing on yield of carrot. Therefore, it can be concluded that the application of water at every 5-days interval and application of 150Kg N/ha combined with 15cm intra-row spacing appeared optimum for yield of carrot.

Keywords: Irrigation; nitrogen; intra row spacing; morphological parameters; carrot and yield

INTRODUCTION

Carrot (*Daucus carota* L.) is an important vegetable because of its high nutritive and medicinal values. It is valued as food because of its high carotene content and vitamin A, which is important in protecting blindness in children. It has long storage life compared to

many other perishable vegetables (Hamma *et al.*, 2012). Accurate information on the yield of carrot in Nigeria is difficult to come by, however, yields of about 4 t/ha have been reported by Hamma *et al.* (2012) under irrigation conditions in Zaria, Nigeria. This is low when compared to yield of 20-40 t/ha obtained in Mauritannia and Niger Republic, 25-45 t/ha in Senegal and the Cape –Verde and 40-50 t/ha in Chad (Lannoy, 2001). This low yield may be attributed to complex issues such as application of adequate amount of water for irrigation, application of nitrogen and optimum population and plant density.

The management of irrigation water is important, since it governs evapotranspiration, water use efficiency, moisture extraction pattern, and nutrient uptake. Furthermore, High irrigation levels of carrots can leach N out from the soil, While, low irrigation levels provide insufficient water for N mineralization and for dissolving $N0_3$. There is the need to determine the optimum irrigation interval for best yield of carrot in the study area.

Nitrogen, generally, has its most profound influence on the vegetative development of crops. When supplied in adequate quantity nitrogen ensures a healthy plant growth, which is manifested by the increased vigour, size and the deeper green colour of the foliage. Unfortunately, most tropical soils are deficient or low in residual nitrogen. Afsar *et al.* (2003) noted that the application of nitrogen had significant influence on the root length, root weight $plant^{-1}$ and had no significant effect on the root diameter of carrots. There is the need to determine the optimum nitrogen rate for best yield of carrot in the study area.

Farmers have not adequately adopted improved recommendations on seed rate, spacing or plant population densities of carrot, which lead to under or over population that ultimately resulted in low yield. Currently, production of the crop is higher in the plateau than in the lowland of the northern guinea savanna; the study was therefore carried out to evaluate the performance of carrot in the lowland of the northern savanna of Dadin-Kowa area. The objective of the research was to determine the influence of irrigation interval, nitrogen levels and intra row spacing on growth and yield of carrot under irrigated conditions in Dadin-Kowa, Yamaltu Deba L.G.A, Area of Gombe State, Nigeria.

MATERIALS AND METHODS

The Study Area

Field trials were conducted during the dry seasons of 2010/2011, 2011/2012 and 2012/2013 at the Teaching and Research Farm of the Federal College of Horticulture Dadin-Kowa, northern guinea savanna ecological zone of Nigeria located on the Latitude 11°30" N, Longitude 10° 200" E at an altitude of 240m above sea level. Data on weather condition such as rainfall, temperature and relative humidity covering the period of the study was collected from the Upper Benue River Basin Development Authority (Metrological Unit) Dadin-Kowa Yamaltu Deba L.G.A., Gombe State as shown in Table 5.

Soil Sample Collection and Analysis

Soil samples from the study area were taken randomly to a depth of 0-30 cm using tubular auger. The samples were mixed thoroughly in a container after which a representative sample was scooped out from the bulk and analyzed to determine the initial soil fertility levels. The pH was measured in water (1:2.5 soil: water) and also in 0.01M $CaCl_2$ using a Cyber Scan 20 pH meter. The soil organic carbon was determined through the wet oxidation

method (Walkley and Black, 1965). The total nitrogen was determined by micro Kjeldahl digestion distillation method (Bremmer, 1965). While available phosphorous was determined by Bray 1 method (Bray and Kurtz, 1945). The exchangeable cations (Ca, Mg, K and Na) and the cation exchange capacity (CEC) were determined using standard procedures as described by Agbenin (1995).

Experimental Design and Field Trial

The treatments, which were laid in a split- split plot design with three replications consist of three irrigation interval (5, 7 and 9 days) and was assigned to the main-plot, four nitrogen levels (0, 50, 100 and 150kg/ha) which was assigned to the sub-plot and three intra row spacing (5,10 and15cm) assigned to sub sub-plot treatments. The experimental plots were properly ploughed and harrowed twice to obtain a fine tilth. A furrow of 75cm in between strip of 2m was dug and used as distributor channel. Later, the strips were encircled with raised bunds, into basins of 2-meter length. Land preparations were carried out in early October.Seeds of carrot were sown at a spacing of 15cm between rows at a sowing depth of about 1cm, which was thinned to one seedling per stand after two weeks of planting. Drainage channels were constructed at the tail end of the field. The variety used for this research was Nantes, which is quite popular and extensively grown by farmers in Northern Nigeria. A dose of half the nitrogen rate and full dose of phosphorus as well as full dose of potassium were applied at two weeks after sowing. Urea (46%N), muriate of potash (60% K_2O) and single superphosphate (18%P_2O_5) were used as sources of nitrogen, phosphorus and potassium, respectively. The second dose of nitrogen was applied as side dressing at six weeks after sowing. Weeds were properly controlled by hand hoe. Three hoe weeding were carried out in each season. No incidence of pest and diseases were recorded throughout the period of experimentation in all seasons.

Data Collection and Analysis

The growth parameters assessed at 9WAS were plant height, length and numbers of leaves. Five plants were selected randomly from each plot and were tagged at 3 WAS for recording various growth and yield parameters. Plant height was recorded from base of the root to the top of the plant and the average plant height was then expressed in cm. Length of leaves was measured from base to the tip of the leaves expressed in cm. The number of leaves in five tagged plants was counted and the average value was worked out. The yield parameters assessed at harvest were length of the carrot, carrot diameter, carrot fresh weight and carrot yield per ha. The length of the carrot was measured in five randomly selected plants from the base of the root to top of the root and average carrot length was expressed in cm. The circumference of five carrots selected randomly was recorded at the basal portion of the root with the help of thread and scale and the average carrot diameter was expressed in cm. The fresh weight of five carrots selected randomly after harvest were recorded and the average fresh weight of carrot was expressed in grams/plant. Total root yield was computed from the yield of net plot and expressed in kg per ha. The data collected were subjected to analysis of variance (ANOVA) and the means were separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of Irrigation Interval on Growth and Yield of Carrot

The combined results showed that 5 day irrigation interval resulted in taller plants, higher number of leaves and higher leave length (Table 3). This was because the soil at the experimental site was sandy loam (Table 1), thus loss of water through deep percolation and evaporation from soil surface would be great, this necessitates frequent irrigation for better performance of the crop. The 5 day interval appeared to meet water needs of the crop, especially when grown on light soils. Nortje and Henrico (1986), reported positive effect of frequent irrigation on vegetative growth of carrot. Availability of water in the crop root zone is very essential for transpiration and tissue formation. Longer irrigation interval resulted in reduced tissue formation resulting from decreased nutrients and water update.

Carrot root length, diameter, fresh weight, and yield (Table 4) increased significantly with 5- day irrigation interval which is an indication of the positive effect of adequate moisture on growth parameters and yield characters, which have direct bearings on the final yield as well as the quality of roots of carrot harvested. The result agreed with the work of Hamma *et al.* (2012) who recommended five days irrigation interval for better growth and yield of carrot in Samaru. Similarly, Slyusar (1986) reported that longer irrigation intervals are known to produce thinner roots and reduced yields in carrot.

Effect of Nitrogen Levels on Growth and Yield of Carrot

The increase in plant height, number of leaves and leaf length of carrot with increasing rate of nitrogen up to 150kg N/ha (Table 3) could be attributed to the positive influence of nitrogen on cell division, cell elongation, cell expansion, synthesis of essential amino acids, enzymes and plant chlorophyll, which all affected the general vigour of the crops. Higher number of leaves per plant indicates more photosynthetic surface, consequently, more assimilate production and translocation. These results agree with the finding of Afsar *et al.* (2003) who reported that increasing application of nitrogen enhances vegetative growth of crops.

As shown in Table 4, the length of root increased at different level of nitrogen application. The highest root was obtained from 150kg N/ha and the lowest root length obtained from control. Root diameter exhibited significant variation with nitrogen level. The biggest root diameter resulted from 150kg N/ha, which was significantly greater than those of the remaining does of nitrogen. These results were in agreement with the work of Ali (1994) who noted that the application of nitrogen had significant influence on the root length in carrot. Similarly; Hamma *et al.* (2012) reported that application of 250 kg /ha of NPK increased both growth and yield of carrot in Zaria. There was significant effect of applied nitrogen dose on fresh weight of individual root. The maximum fresh weight of root per plant was recorded where 150kgN/ha was the current result confirms the indirect effect of N-fertilization on increased root weight in carrot. This root weight augmentation could be due to increase in vegetative growth and hence increased food production and assimilation in to root parts. The highest yield was obtained from 150kg N/h application. The increase in yield of carrot root might be attributed to higher individual root weight, higher number of leaves per plant, higher root dry matter content. The treatments with taller plants and higher number of laves per plant had higher root yield. It might be due to increased photosynthesis in those

treatments which resulted in higher food production and storage of produced food in storage roots.

Effect of Intra Row Spacing on Growth and Yield of Carrot

The increase in plant height, number of leaves per plant, leaf length per plant of carrot, higher carrot root length, root diameter, fresh weight of root and carrot root yield compared to planting of carrot at 5 or 10cm intra row spacing (Table 3 and 4) could be probably due to the fact that, carrot plants grown at wide intra-row spacing are less exposed to intra specific competition for nutrient, moisture, light and space, therefore tend to grow vigorously. The lower values obtained at closer spacing could be due to intense competition for light, nutrients and space. The implication is that at wider spacing more photosynthesis would be produced by the source and in turn translocated to the sink, thus resulting in higher yield of carrot.

Interaction effect of nitrogen and spacing

There was significant difference in yield of carrot per ha from the interaction effect of nitrogen level of 150kgN/ha with the intra-row spacing of 15cm (Figure 1).This could be due to the fact that nitrogen nutrition is usually enhanced by the wider spacing, specifically due to the effect of wider spacing on root development, formation and transfer which improves the efficiency of nutrient uptake and thus synthesis of assimilate. Similar results were reported by Hassan et *al* (1992).

CONCLUSION

Based on the results of the study it can be concluded that application of water at every 5-day interval and application of 150Kg N/ha combined with 15cm intra-row spacing resulted in optimum growth and yield of carrot in Yamaltu Deba Local Government Area of Gombe State, Nigeria. Therefore, farmers in the study area are advised to adopt this recommendation for optimum production of carrot.

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Table 1: Physico-chemical characteristics of soils of the experimental site in 2010, 2011 and 2012 dry seasons at Dadin-Kowa

Soil composition		Soil depth 0 – 30 cm		
	Units	2010	2011	2012
Particle size	g/kg			
Clay		22.32	21.3	22.44
Silt		18.56	18.4	19.42
Sand		59.12	60.03	58.14
Textural class		Sandy clay	Sandy clay	Sandy clay
Chemical properties				
pH (water)		7.2	7.6	7.4
pH ($CaCl_2$)		6.5	6.7	6.6
Organic Carbon	g/kg	0.58	0.61	0.63
Available P	mg/kg	6.25	6.29	6.32
Total Nitrogen	g/kg	0.07	0.1	0.09
Exchangeable Cations	cmol/kg			
Ca		2.63	2.69	2.67
Mg		0.63	0.78	0.79
K		0.18	0.22	0.26
Na		0.08	0.1	0.17
CEC	cmol/kg	9.25	9.47	9.52

Table 2: Growth parameters of carrot as influenced by irrigation interval, nitrogen levels and intra row spacing during 2010, 2011 and 2012 dry seasons and combine at 9 WAS Dadin Kowa

	Plant height (cm)				Number of leaves				Leaf length (cm).			
Treatment	2010	2011	2012	combined	2010	2011	2012	combined	2010	2011	2012	combined
Irrigation interval (Days)												
5	19.95a	17.89a	16.67a	18.17a	5.53a	5.21a	5.07a	5.27a	14.84a	13.81a	12.21a	13.62a
7	17.96b	15.90b	14.73b	16.20b	5.08b	4.68b	4.36b	4.71b	12.87b	11.86b	11.33b	12.02b
9	17.14c	15.11c	14.06c	15.44c	4.84c	4.43c	4.11c	4.46c	12.07c	11.08c	10.89c	11.35c
SE (±)	0.140	0.130	0.140	0.140	0.047	0.038	0.018	0.034	0.140	0.130	0.110	0.130
Nitrogen levels (Kg/ha)												
0	15.61d	14.62d	13.45d	14.60d	4.16d	3.97d	3.43d	3.85d	11.59d	14.62d	14.13d	13.45d
50	18.26c	17.16c	16.03c	17.15c	5.07a	4.91c	4.56c	4.85c	14.13c	17.16c	16.84c	16.04c
100	20.24b	19.21b	18.08b	19.18b	5.58b	5.46b	5.13b	5.39b	16.17b	19.21b	18.42b	17.93b
150	21.37a	20.38a	19.19a	20.31a	5.77a	5.71a	5.39a	5.62a	17.35a	20.38a	19.20a	18.98a
SE (±)	0.080	0.060	0.160	0.100	0.032	0.023	0.012	0.023	0.160	0.140	0.120	0.140
Intra row spacing (cm)												
5	17.75c	16.67c	15.46c	16.63c	4.91c	4.72c	4.22c	4.62c	13.62c	12.61c	11.67c	12.63c
10	18.38b	17.40b	16.25b	17.34b	5.16b	4.97b	4.43b	4.85b	14.39b	13.38b	12.71b	13.49b
15	18.91a	17.93a	16.79 a	18.19a	5.36a	5.18a	4.98a	5.17a	14.91a	13.93a	13.03a	13.96a
SE (±)	0.050	0.040	0.110	0.060	0.029	0.024	0.019	0.024	0.150	0.140	0.160	0.150
Interactions												
I × N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × S	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS
I × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I × N ×S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different at 5% percent level of significance. NS= not significant **= significant interaction but the interaction was not reported in this work.

Table 3: Yield parameters of carrot as influenced by irrigation interval, nitrogen levels and intra row spacing during 2010, 2011 and 2012 dry season and combine at harvest in Dadin Kowa

	Carrot length (cm)				Carrot diameter (cm)				Carrot fresh weight (g)			
Treatment	2010	2011	2012	combined	2010	2011	2012	combined	2010	2011	2012	combined
Irrigation interval (Days)												
5	14.01a	13.11a	12.94a	13.35a	2.51a	3.21a	3.06a	2.935	7.16a	58.51a	57.16a	57.61a
7	13.52b	12.65b	12.40b	12.86b	2.93b	2.71b	2.57b	2.745	5.21b	58.60b	56.05b	56.62b
9	13.31c	12.42c	12.03c	12.59c	2.69c	2.42c	2.33c	2.48	54.19c	52.17c	55.38c	53.91c
SE (±)	0.046	0.048	0.032	0.042	0.036	0.031	0.260	0.029	0.004	0.004	0.003	0.004
Nitrogen levels (Kg/ha)												
0	12.61d	11.66d	11.12d	11.80d	2.11d	2.03d	1.97d	2.04	53.37d	51.16d	50.46d	51.66d
50	12.93c	11.95c	11.56c	12.15c	2.71c	2.47c	2.36c	2.51	54.78c	52.42c	51.26c	52.82c
100	13.71b	12.76b	12.09b	12.85b	3.13b	2.96b	2.81b	2.97	56.69b	54.62b	53.20b	54.84b
150	14.13a	13.93a	12.94a	13.67a	4.09a	3.89a	3.14a	3.71	59.24a	57.31a	56.92a	57.82a
SE (±)	0.054	0.047	0.031	0.044	0.045	0.042	0.027	0.038	0.007	0.005	0.004	0.005
Intra row spacing (cm)												
5	13.11c	12.16c	11.21c	12.16c	2.78c	2.43c	2.19	2.47	55.19c	53.16c	53.05c	53.80c
10	13.23b	12.58b	11.49b	12.43b	2.99b	2.76b	2.41	2.72	55.89b	53.72b	53.69b	54.43b
15	13.61a	12.92a	11.92a	12.82a	3.44a	3.19a	2.98	3.2	57.11a	55.17a	54.97a	55.75a
SE (±)	0.043	0.040	0.036	0.040	0.001	0.006	0.004	0.005	0.005	0.006	0.004	0.005
Interactions												
I × N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I × N × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different at 5% percent level of significance. NS- not significant

Table 4: Root yield of carrot as influenced by irrigation interval, nitrogen levels and intra row spacing during 2010, 2011 and 2012 dry seasons and combined at harvest at Dadin-Kowa

Treatment	Root yield (Kg/ha) 2010	2011	2012	combined
Irrigation interval (Days)				
5	10.58a	10.36a	10.05a	10.33a
7	8.07b	7.82b	7.69b	7.86b
9	7.13c	6.91c	6.84c	6.96c
SE (±)	0.023	0.021	0.020	0.022
Nitrogen levels (Kg/ha)				
0	4.82d	4.61d	4.47d	4.63d
50	7.07c	6.82c	6.71c	6.87c
100	10.04b	9.81b	8.92b	9.59b
150	12.45a	12.22a	11.04a	11.90a
SE (±)	0.007	0.004	0.006	0.006
Intra row spacing (cm)				
5	7.63c	7.40c	6.92c	7.32c
10	8.54b	8.31b	7.86b	8.24b
15	9.62a	9.39a	9.11a	9.37a
SE (±)	0.006	0.003	0.004	0.004
Interactions				
I × N	NS	NS	NS	NS
N × S	**	NS	NS	NS
I × S	NS	NS	NS	NS
I × N × S	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different at 5% percent level of significance. NS- not significant **= significant interaction

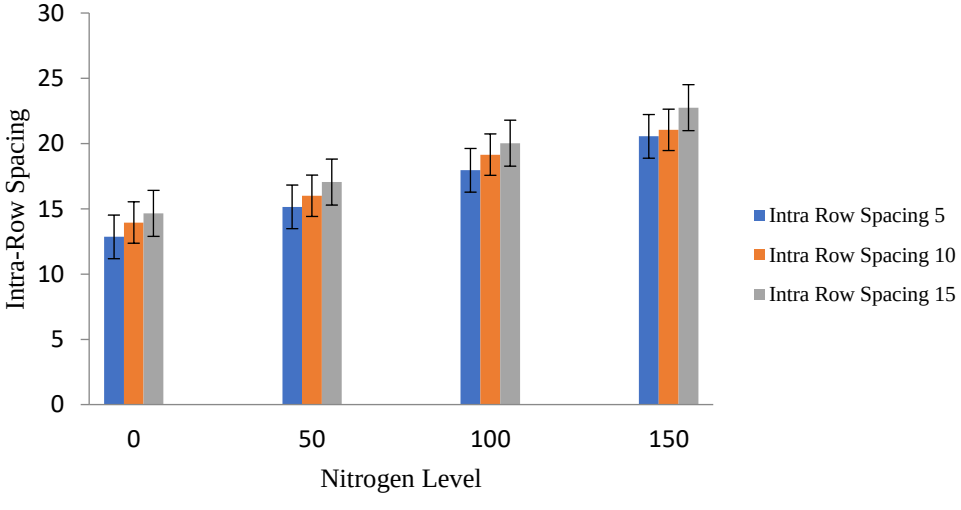

Fig. 1: Interaction effect of intra-row spacing and nitrogen level on root yield of carrot

Table 5: Meteorological Data of the study area in 2010, 2011 and 2012

Meteorological Data in 2010						
Month	Rainfall (mm)	Temperature (°C) Max	Min	Wind speed km/hr	Evap	SS (Hrs)
January	--	29.00	15.00	1.75	5.72	6.92
February	--	30.00	20.00	0.63	9.47	8.96
March	--	34.00	21.00	3.42	8.20	7.50
April	41.70	34.00	25.00	161.16	8.41	8.62
May	14.80	35.00	25.00	154.46	8.69	8.70
June	21.40	33.00	24.00	92.78	7.14	7.00
July	207.20	30.20	24.00	105.05	9.01	6.70
August	198.50	30.00	24.00	76.39	3.72	5.50
September	123.90	31.00	24.00	3.62	4.30	6.40
October	108.90	35.00	25.00	4.00	4.62	5.80
November	--	36.00	19.00	1.82	8.18	7.00
December	--	32.00	15.00	2.79	5.32	6.80
Meteorological Data for 2011						
Month	Rainfall (mm)	Temperature (°C) Max	Min	Wind speed km/hr	Evap	SS (Hrs)
January	--	30.00	13.00	10.24	7.50	5.00
February	--	32.00	18.00	131.25	8.60	6.40
March	--	36.00	23.00	252.11	8.15	7.80
April	1.30	35.00	23.00	80.95	7.88	7.20
May	74.10	35.00	25.00	72.12	8.56	7.20
June	106.10	33.00	24.00	494.00	6.26	6.90
July	199.10	30.29	23.00	91.10	7.50	7.10
August	196.90	31.00	24.00	73.20	5.56	4.40
September	116.70	32.00	23.00	81.10	4.94	5.80
October	87.80	36.00	24.00	74.20	4.95	6.20
November	--	36.00	16.90	68.40	6.33	6.80
December	--	34.00	15.70	80.00	5.73	6.40
Meteorological Data for 2012						
Month	Rainfall (mm)	Temperature (°C) Max	Min	Wind speed km/hr	Evap	SS (Hrs)
January	--	32.00	28.00	10.24	7.50	5.60
February	--	34.00	18.00	13.25	8.15	6.90
March	--	36.00	25.00	252.11	8.60	7.80
April	21.80	39.00	27.00	80.95	8.15	7.80
May	96.50	37.00	25.00	72.12	7.88	8.20
June	130.70	32.00	24.00	494.00	8.56	7.10
July	284.10	31.29	23.60	91.10	6.26	7.10
August	199.60	31.00	24.00	73.20	7.50	4.70
September	201.40	32.00	24.00	81.10	5.56	6.10
October	88.70	36.00	24.00	74.20	4.94	6.40
November	--	36.00	25.90	68.40	6.33	6.80
December	--	35.00	15.70	80.00	5.73	6.40