Vertical distribution of nutrients in groundnut growing soils in semiarid region of Yerpedu mandal in Chittoor district, Andhra Pradesh

GP Leelavathi and MVS Naidu

DOI: https://doi.org/10.22271/chemi.2020.v8.i4s.9898

Abstract
A survey was undertaken to study vertical distribution of nutrients in the soil profiles/ pedons arranged in groundnut growing areas of Yerpedu mandal in Chittoor district, Andhra Pradesh to understand nutrients supplying capacity of lower layers of soil profiles. The results revealed that, the available P in groundnut growing soils was sufficient in the surface and subsurface horizons of all the pedons except pedon 5 wherein P was deficient in subsurface horizon while the available K was sufficient in surface horizons but deficient to sufficient in subsurface horizons in all the pedons. However, the available S in groundnut growing soils was high in surface horizons than in subsurface horizons whereas exchangeable Ca and Mg showed an irregular trend with depth. The DTPA-extractable Zn, Fe, Cu and Mn in groundnut growing soils were found to be above their critical limits in surface and subsurface horizons in all the pedons except in pedons 4 and 5 for Fe in surface and subsurface horizons and Mn in subsurface horizons. All the micronutrients were higher in surface soils than subsurface soils except in pedons 4 and 5 for Fe.

Keywords: Macronutrients and micronutrients, organic carbon, pH, subsoil and surface soil

Introduction
Knowledge of vertical distribution of plant nutrients in soil is useful as roots of most of the crops go beyond the surface layer and draw part of their nutrient requirement from the subsurface layers of the soil. Most of the researchers have limited their studies on fertility status of surface layer only. Very few have attempted to study layer wise fertility status of soils, which is very important for effective nutrient application. For efficient nutrient management the depth wise distribution of nutrients in soil profiles is highly essential for achieving sustainable yields (Ramalakshami and Sheshagiri Rao, 2000). Though sporadic information is available regarding depth wise distribution of macro and micronutrients, however detailed information regarding the vertical distribution of macronutrients status in groundnut growing soils of Chittoor district in particular and in general in Andhra Pradesh is very much lacking. Hence, present survey was conducted to study the depth wise distribution of nutrients in groundnut growing soils of Yerpedu mandal in Chittoor district, Andhra Pradesh, since groundnut is the major crop in study area.

Materials and Methods
Location and Agro-climate: Yerpedu mandal of Chittoor district, Andhra Pradesh lies in between 13°36’ and 13°40’ North latitude and 79°18’ and 79°28’ East longitude covering an area of 18971.00 ha. The climate of the study area is semi-arid monsoonic with mean annual rainfall of 1203.66 mm, of which 90 per cent is received during June to December. The mean annual temperature is 27°C with mean summer temperature of 31°C and the mean winter temperature of 27°C. The maximum temperature is recorded in the month of May that rises to 39°C and the minimum temperature is 25°C in the month of December. The soil moisture regime is ustic and soil -temperature regime iso-hyperthermic.

Field survey and Taxonomic classification: Reconnaissance soil survey was conducted and five pedons were arranged in the groundnut growing areas of Yerpedu mandal in Chittoor district, Andhra Pradesh. The taxonomy of these five pedons viz., Pallam pedon (P1- Fine,
kaolinitic, iso-hyperthermic, Typic Haplusterts), Gudimallam pedon (P2- Fine-loamy, mixed, iso-hyperthermic, Ultic Haplustalfs), Merakapatra pedon (P3- Fine, smectitic, iso-hyperthermic, Typic Haplusterts), Pennagadam pedon (P4- Sandy, siliceous, iso-hyperthermic, Typic Ustisamments) and Munagalapalem pedon (P5- Fine-loamy, siliceous, iso-hyperthermic, Typic Ustifluvents). The horizon wise soil samples were collected for detailed analysis. The pedons P1 and P3 belongs to Inceptisols, P4 and P5 were grouped under Entisols and P2 was classified into Alfisols. The soil samples were processed and analyzed for available macronutrients, available and total micronutrients using standard methods as described by Jackson (1973) [4].

The critical limits proposed by Patel and Savani (1987) [7] for available P (13 kg P ha⁻¹), Aulakh et al. (1988) [8] for available K (150 kg K ha⁻¹), Tandon (1991) [14] for exchangeable Ca (1.5 cmol (p+) kg⁻¹), Mg (1.0 cmol (p+) kg⁻¹) and available S (10 mg kg⁻¹), Anon (1977) [1] for Zn (0.75 mg kg⁻¹), and Tandon (1993) [15] for Fe (4 mg kg⁻¹), Cu (0.5 mg kg⁻¹) and Mn (2 mg kg⁻¹) were followed for classifying profile soil samples into sufficient or deficient with respect to above nutrients for groundnut.

Results and Discussion

The groundnut growing soils were slightly acidic to strongly alkaline in reaction (6.54-8.99) and this wide variation in pH was attributed to the nature of the parent material, leaching, presence of calcium carbonate, exchangeable sodium and the release of organic acids during decomposition of organic matter (Devi et al. 2015) [5]. The texture of the groundnut growing soils varied from sand to sandy clay and this wide textural variation was caused by topographic position, nature of parent material, in situ weathering and translocation of clay (Leeavathi et al. 2009) [6]. The EC in groundnut growing soils ranged from 0.03 to 0.24 dSm⁻¹ indicating the non-saline. The low EC of groundnut growing soils was due to free drainage conditions which favoured the removal of released bases by percolating and drainage water (Sashikala et al. 2019) [11]. The organic carbon content of the groundnut growing soils was low (0.05 to 0.44 per cent), which might be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetation cover, there by leaving less organic carbon in the soils (Supriya et al. 2019) [13].

Macronutrients: The available phosphorus varied from 10.37 to 19.17 kg ha⁻¹ in all the pedons of groundnut growing areas with a mean of 14.93 kg ha⁻¹ (Table 1). Taking 13 kg P ha⁻¹ as critical level, the available P status was sufficient in the surface and subsurface soils except in pedon 5 (Munagalapalem) showing deficiency in subsurface horizons. In all the pedons of groundnut growing areas, the available P content decreased with depth, which might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted phosphorus by external sources i.e., fertilizers and presence of free iron oxide and exchangeable Al³⁺ in smaller amounts. The lower phosphorus content in sub-surface horizons could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminum (Kumar and Naidu, 2012) [5]. The available potassium content of groundnut growing soils varied from 30.24 to 669.76 kg ha⁻¹ with a mean value 212.5 kg ha⁻¹. Based on 150 kg ha⁻¹ as a critical limit, the highest available potassium content was observed in the surface horizons and showed more or less a decreasing trend with depth in pedon 2 (Gudimallam), pedons 3 (Merlapaka) and pedon 4 (Pennagadam). This could be ascribed to more weathering of the potassium bearing minerals, application of K fertilizers and upward translocation of potassium from lower depths along with capillary raise of ground water (Vedadri and Naidu, 2018) [17]. The exchangeable Ca in groundnut growing soils ranged from 2.10 to 16.86 cmol (p⁺) kg⁻¹ of soil with a mean of 8.27 cmol (p⁺) kg⁻¹ of soil. Similarly the exchangeable Mg in groundnut growing areas was found to vary from 0.80 to 5.80 cmol (p⁺) kg⁻¹ of soil with a mean of 3.43 cmol (p⁺) kg⁻¹ of soil (Table 1). Taking 1.5 cmol (p⁺) kg⁻¹ of soil for Ca and 1 cmol (p⁺) kg⁻¹ of soil for Mg as critical limits, the exchangeable Ca and Mg in both the surface and sub-surface horizons of all the pedons of groundnut growing areas, were found to be sufficient. The exchangeable Ca was found to be the dominant cation followed by Mg on the exchange complex, because of its higher mobility, earlier removal than the later and also Ca dominates in the prevailing semi-arid weathering environment and consequently occupied the major portion on the exchange complex in the groundnut growing soils (Reddy and Naidu, 2016) [10].

The available sulphur in groundnut growing soils varied from 12.50 to 58.75 mg kg⁻¹ with a mean of 36.66 mg kg⁻¹ (Table 1). Taking 10 mg S kg⁻¹ soil as critical value, the available sulphur was sufficient in all surface and sub-surface horizons of groundnut growing areas. Surface horizons in the pedons of groundnut growing areas contained more available sulphur than subsurface horizons except Bv2 horizon of pedon 3 (Merlapaka profile) which could be due to higher amount of organic matter in surface layers than in deeper layers. A significant correlation between organic carbon and available sulphur confirmed the above trend. Similar type of correlation was also observed by Thangasamy et al. (2005) [16].

Micronutrients: The total zinc content in the soil profiles of groundnut growing areas was varied from 9.05 mg kg⁻¹ to 28.00 mg kg⁻¹ with a mean of 14.83 mg kg⁻¹, while available Zn in groundnut growing areas varied from 0.20 mg kg⁻¹ to 1.30 mg kg⁻¹ with a mean of 0.79 mg kg⁻¹ (Table 2). Further, by taking 0.75 mg Zn kg⁻¹ soil as critical limit, surface horizons in all pedons of groundnut growing areas are above the critical limit and sub-surface horizons of all pedons of groundnut growing areas except pedon 2 (Gudimallam profile) exhibited lower values than critical limit. Lower available Zn in deeper layers was due to low amount of organic carbon in these deeper layers which was confirmed by significant and positively correlation (r =+0.404) of Zn with organic carbon. Similar findings were reported by Sireesha and Naidu (2013) [12].

The total iron status of all the pedons of groundnut growing areas was found to be varied between 0.83 and 4.96 per cent with an average of 2.53 per cent whereas available Fe in the same groundnut growing areas varied from 0.46 to 10.13 mg kg⁻¹ soil with a mean of 3.09 mg kg⁻¹ soil (Table 2). According to critical limit of 4 mg kg⁻¹ soil, the groundnut growing soils were deficient in available Fe content except Ap horizon of pedons 1, 2, 3, 5 and A1, E and Bt1 horizons of pedon 2 (Gudimallam profile). The distribution of available iron in all the pedons of groundnut growing areas did not show a definite pattern but abruptly decreased. It might be due to accumulation of organic carbon and prevalence of reduced conditions in the surface horizons. The organic carbon due to its affinity to influence the solubility and availability of iron by chelation effect might have protected
the iron from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991). Total copper content in the pedons of groundnut growing areas varied from 1.75 to 20.00 mg kg$^{-1}$ with a mean of 5.98 mg kg$^{-1}$ while available copper in the pedons of groundnut growing areas was ranged from 0.21 to 2.56 mg kg$^{-1}$ with an average of 1.24 mg kg$^{-1}$. Based on 0.5 mg Cu kg$^{-1}$ soil as a critical limit the available copper in groundnut growing areas was sufficient in the horizons of all pedons except C2 horizon of pedon 5 (Munagalapalem profile). Available copper was positively correlated ($r=+0.344$) with organic carbon because of pedon 5 (Munagalapalem profile). Available copper was sufficient in the horizons of all pedons except C2 horizon (Munagalapalem) and subsurface horizons of pedon 4 (Pennagadam) was found to be adequate as per the critical limit of 2 mg Mn kg$^{-1}$ soil. In general the higher Mn in surface and subsurface horizons might be derived from the parent material. The study revealed that the groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh were classified into Entisols (Typic Ustisamments and Typic Ustifluvents), Inceptisols (Typic Haplustepts) and Alfisols (Ultic Haplustalfs). The groundnut growing soils were slightly acidic to strongly alkaline, non-saline and low in organic carbon. The groundnut growing soils were sufficient in available phosphorus, sulphur and exchangeable calcium and magnesium in surface and subsurface soils. However, the available phosphorus was sufficient in surface soils but sufficient to deficient in subsurface soils. The DTPA-extractable Zn, Fe, Cu and Mn in groundnut growing soils were found to be above their critical limits in surface and subsurface horizons in all the pedons except in pedons 4 and 5 for Fe in surface and subsurface horizons and Mn in subsurface horizons. Hence, judicious use of organics with inorganics not only sustains soil fertility of groundnut growing soils but also sustains productivity of groundnut growing soil.

**Conclusion**

The study revealed that the groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh were classified into Entisols (Typic Ustisamments and Typic Ustifluvents), Inceptisols (Typic Haplustepts) and Alfisols (Ultic Haplustalfs). The groundnut growing soils were slightly acidic to strongly alkaline, non-saline and low in organic carbon. The groundnut growing soils were sufficient in available phosphorus, sulphur and exchangeable calcium and magnesium in surface and subsurface soils. However, the available phosphorus was sufficient in surface soils but sufficient to deficient in subsurface soils. The DTPA-extractable Zn, Fe, Cu and Mn in groundnut growing soils were found to be above their critical limits in surface and subsurface horizons in all the pedons except in pedons 4 and 5 for Fe in surface and subsurface horizons and Mn in subsurface horizons. Hence, judicious use of organics with inorganics not only sustains soil fertility of groundnut growing soils but also sustains productivity of groundnut growing soil.

**Table 1**: Macronutrient status of groundnut growing soils of Yerpedu mandal of Chittoor district, Andhra Pradesh

| Depth (cm) | Horizon | Available (kg ha$^{-1}$) | Exchangeable c mol(p+1)kg$^{-1}$ | S (mg kg$^{-1}$) |
|------------|---------|--------------------------|-------------------------------|----------------|----------------|
|            |         | P                        | K                             | Ca             | Mg             |
| Pedon 1: Pallam |
| 0.00-0.25  | Ap      | 16.82                    | 241.92                        | 9.4            | 2.4            | 43.70          |
| 0.25-0.50  | A$_1$   | 14.87                    | 156.80                        | 10.8           | 4.9            | 12.50          |
| 0.50-0.85  | Bw$_1$  | 14.09                    | 199.36                        | 16.71          | 5.8            | 33.75          |
| 0.85-1.17  | Bw$_2$  | 13.31                    | 207.20                        | 16.86          | 5.4            | 33.75          |
| 1.17-1.51  | Bw$_3$  | 14.87                    | 183.68                        | 10.26          | 4.3            | 37.50          |
| 1.51-1.90+ | C       | 14.87                    | 47.04                         | 6.8            | 2.0            | 31.25          |
| Pedon 2: Gudimallam |
| 0.00-0.12  | Ap      | 18.77                    | 669.76                        | 6.4            | 1.9            | 46.25          |
| 0.12-0.25  | A$_1$   | 18.59                    | 596.96                        | 6.8            | 2.2            | 38.75          |
| 0.25-0.49  | E       | 14.87                    | 588.00                        | 5.5            | 3.3            | 33.75          |
| 0.49-0.78  | Bt$_1$  | 14.09                    | 424.48                        | 7.6            | 1.6            | 43.75          |
| 0.78-1.11  | Bt$_2$  | 14.87                    | 246.40                        | 7.6            | 3.3            | 33.75          |
| 1.11-1.40  | C       | 13.31                    | 262.08                        | 7.0            | 2.2            | 33.75          |
| Pedon 3: Merlapaka |
| 0.00-0.22  | Ap      | 19.17                    | 196.00                        | 6.7            | 4.0            | 43.75          |
| 0.22-0.56  | Bw$_1$  | 17.23                    | 127.68                        | 9.8            | 5.5            | 38.75          |
| 0.56-0.78  | Bw$_2$  | 15.66                    | 90.72                         | 12.6           | 5.5            | 58.75          |
| 0.78-0.96  | Bw$_3$  | 13.31                    | 31.36                         | 10.3           | 3.8            | 38.75          |
| 0.96-1.20+ | C       | 12.90                    | 39.20                         | 9.6            | 3.2            | 40.00          |
| Pedon 4: Pennagadam |
| 0.00-0.22  | Ap      | 16.82                    | 155.68                        | 5.1            | 2.1            | 33.75          |
| 0.22-0.40  | A$_1$   | 16.82                    | 114.24                        | 3.2            | 1.6            | 27.50          |
| 0.40-0.71  | A$_2$   | 15.66                    | 97.44                         | 2.8            | 1.2            | 31.25          |
| 0.71-1.10+ | A$_3$   | 12.90                    | 87.36                         | 2.1            | 0.8            | 33.75          |
| Pedon 5: Munagalapalem |
| 0.00-0.20  | Ap      | 14.87                    | 320.32                        | 9.1            | 4.7            | 43.75          |
| 0.20-0.46  | A$_1$   | 12.90                    | 234.08                        | 9.4            | 5.3            | 38.75          |
| 0.46-0.70  | A$_2$   | 12.90                    | 150.08                        | 9.1            | 4.8            | 38.75          |
| 0.70-1.03  | C$_1$   | 17.74                    | 30.24                         | 7.8            | 4.3            | 35.00          |
| 1.03-1.37  | C$_2$   | 10.37                    | 57.12                         | 7.0            | 3.4            | 31.25          |
| 1.37-1.90+ | C$_3$   | 10.57                    | 184.80                        | 6.9            | 3.0            | 33.75          |
| Mean       |         | 14.93                    | 212.50                        | 8.27           | 3.43           | 36.66          |
| Range      |         | 10.37-19.17              | 30.24-669.76                  | 2.1-12.6       | 0.8-5.5        | 12.50-58.75    |
| Pedon 1: Pallam | Zn (mg kg⁻¹) | Total | Available |
|----------------|-------------|-------|-----------|
| 0.00-0.25 Ap   | 11.35       | 1.04  | 2.70      |
| 0.25-0.50 A₁   | 13.10       | 0.76  | 4.96      |
| 0.50-0.85 B₁    | 10.65       | 0.61  | 1.52      |
| 0.85-1.17 B₂    | 14.30       | 0.20  | 3.28      |
| 1.17-1.51 B₃    | 10.33       | 0.31  | 3.63      |
| 1.51-1.90+ C    | 10.78       | 0.78  | 1.73      |

| Pedon 2: Gudimallum | Zn (mg kg⁻¹) | Total | Available |
|---------------------|-------------|-------|-----------|
| 0.00-0.12 Ap        | 15.90       | 1.30  | 2.20      |
| 0.12-0.25 A₁        | 9.70        | 0.99  | 1.78      |
| 0.25-0.49 E         | 11.78       | 1.21  | 2.06      |
| 0.49-0.78 B₁        | 26.40       | 1.10  | 3.91      |
| 0.78-1.11 B₂        | 20.85       | 1.20  | 3.91      |
| 1.11-1.40 C         | 18.40       | 1.09  | 2.91      |

| Pedon 3: Merlapaka | Zn (mg kg⁻¹) | Total | Available |
|-------------------|-------------|-------|-----------|
| 0.00-0.22 Ap      | 12.43       | 0.84  | 4.00      |
| 0.22-0.56 B₁      | 16.78       | 0.43  | 2.19      |
| 0.56-0.78 B₂      | 12.45       | 0.37  | 1.85      |
| 0.78-0.96 B₃      | 10.77       | 0.45  | 0.92      |
| 0.96-1.20+ C      | 15.23       | 0.35  | 1.80      |

| Pedon 4: Pennagadam | Zn (mg kg⁻¹) | Total | Available |
|---------------------|-------------|-------|-----------|
| 0.00-0.22 Ap        | 15.58       | 0.99  | 1.20      |
| 0.22-0.40 A₁        | 28.00       | 0.69  | 0.83      |
| 0.40-0.71 A₂        | 9.53        | 0.80  | 0.97      |
| 0.71-1.10+ A₃       | 9.05        | 0.74  | 1.83      |

| Pedon 5: Munagalapalem | Zn (mg kg⁻¹) | Total | Available |
|------------------------|-------------|-------|-----------|
| 0.00-0.20 Ap           | 18.40       | 1.28  | 4.42      |
| 0.20-0.46 A₁           | 10.30       | 0.83  | 3.66      |
| 0.46-0.70 A₂           | 18.80       | 0.71  | 4.14      |
| 0.70-1.03 C₁           | 14.73       | 0.78  | 2.61      |
| 1.03-1.37 C₂           | 20.08       | 0.69  | 1.47      |
| 1.37-1.90+ C₃          | 14.63       | 0.71  | 3.72      |
| Mean                   | 14.83       | 0.79  | 2.53      |
| Range                  | 9.05-28.00  | 0.20-1.30 | 0.83-4.96 | 0.46-10.13 | 1.75-20.00 | 0.21-2.56 | 45-590 | 0.89-19.93 |

Acknowledgment
The senior author is highly grateful to the Acharya N.G. Ranga Agricultural University, Gunur, Andhra Pradesh for providing financial assistance in the form of stipend during course of investigation.

References
1. Anon. All India Coordinated Research Project on Micronutrient in Soils and Plants. Annual Report for 1997-1978, APAU, Hyderabad, India, 1977.
2. Aulakh MS, Pasricha NS, Dhillon KS, Baddesha HS, Bahl GS. Content and uptake of nutrients by pulses and oilseed crops. Indian Journal of Ecology. 1988; 12(2):238-242.
3. Devi PAV, Naidu MVS, Rama Krishna Rao A. Characterization and classification of sugarcane growing soils in southern arid-climatic zone: A case study in eastern mandals of Chittoor district in Andhra Pradesh. Journal of the Indian Society of Soil Science. 2015; 63(3):245-258.
4. Jackson ML. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi, 1973.
5. Kumar YSS, Naidu MVS. Characterization and classification of soils representing major landforms in Vadamalapeta mandal of Chittoor district, Andhra Pradesh. Journal of the Indian Society of Soil Science. 2012; 60(1):63-67.
6. Leelavathi GP, Naidu MVS, Ramavatharam N, Sagar GK. Studies on genesis, classification and evaluation of soils for sustainable land use planning in Yerpedu mandal of Chittoor district, Andhra Pradesh. Journal of the Indian Society of Soil Science. 2009; 57(2):109-120.
7. Patel MS, Savani RP. Suitability of Olsen’s extract for available P for groundnut growing soils of Saurashtra. Journal of the Indian Society of Soil Science. 1987; 35:155-157.
8. Prasad SN, Sakal R. Availability of iron in calcareous soils in relation to soil properties. Journal of the Indian Society of Soil Science. 1991; 39:658-661.
9. Ramalakshmi S, Seshagiri Rao M. Depthwise distribution of nutrients in some Inceptisols, Vertisols and Entisols of Bapatla and Karlapalem region of Guntur district. The Andhra Agricultural Journal. 2020; 47:50-54.
10. Reddy SK, Naidu MVS. Characterization and classification of soils in semi-arid region of Chennur mandal in Kadapa district, Andhra Pradesh. Journal of the Indian Society of Soil Science. 2016; 64(3):207-217.
11. Sashikala G, Naidu MVS, Ramana KV, Nagamadhuri KV, Prathap Kumar A, Reddy P et al. Characterization and Classification of Soils in Semi-arid Region of Tatarkatlu Village of Anantapuramu District in Andhra Pradesh. Journal of the Indian Society of Soil Science. 2019; 67(4):389-401.
12. Sireesha PVG, Naidu MVS. Studies on genesis, characterization and classification of soils in semi-arid Agro-ecological region: A case study in Banaganapalle mandal of Kurnool district, Andhra Pradesh. Journal of the Indian Society of Soil Science. 2013; 61(3):167-178.
13. Supriya K, Naidu MVS, Kavitha P, Srinivasa Reddy M. Characterization, classification and evaluation of soils in semi-arid region of Mahanandi mandal in Kurnool district of Andhra Pradesh. Journal of the Indian Society of Soil Science. 2019; 67(2):125-136.

14. Tandon HLS. Secondary and Micronutrient in Agriculture-Guide book-cum-Directory, FDCO, New Delhi, 1991.

15. Tandon HLS. Methods of analysis of Soils, Plants, Waters and Fertilizer. FDCO, New Delhi, 1993.

16. Thangasamy A, Naidu MVS, Ramavatharam N, Reddy CR. Characterization, classification and evaluation of soil resources in Sivagiri micro watershed of Chittoor district in Andhra Pradesh for sustainable land use planning. Journal of the Indian Society of Soil Science. 2005; 53(1):11-21.

17. Vedadri U, Naidu MVS. Characterization, classification and evaluation of soils in semi-arid ecosystem of Chillakur mandal in SPSR Nellore district of Andhra Pradesh. Journal of the Indian Society of Soil Science. 2018; 66(1):9-19.

18. Venkatesu T, Venkaiah K, Naidu MVS. Depthwise distribution of nutrients in groundnut growing soils of Nellore district in Andhra Pradesh. Journal of Oilseeds Research. 2002; 19(2):185-189.