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# Root distribution pattern in two age groups of litchi plants growing under Alfisols of Eastern plateau and hill region of India

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## ABSTRACT

The investigations were carried out at ICAR RCER, Research Centre, Plandu, Ranchi, Jharkhand during 2011 and 2012 to study the pattern of root distribution in Young bearing (age 8-10 years) and Senior-adult bearing plants (age >25 years) of litchi cv. Shahi growing under alfisols of eastern plateau and hill region. Core sampling technique was followed for collecting roots from different depths of soil (0-30 cm, 30-60 cm and 60-90 cm) at distances from trunk at 50 cm intervals (50 to 450 cm from trunk in of senior adult bearing plants and 50-300 cm in young bearing plants) in both North and South directions. Data were recorded on weights of different grades of roots Grade-1 (diameter <1mm), Grade-2 (diameter 1-3 mm), Grade-3 (diameter 3-5 mm), Grade-4 (diameter >5mm). In both the types of plants, the total root weight in south aspect was higher than that in north aspect of tree. The investigations clearly indicated presence of higher amount of finer roots at a distance between 250-350 cm from the trunk in case of senior adult bearing trees and at a distance of 250-300 cm from the trunk in case of young bearing trees.

*Key words :*

## Introduction

Litchi (*Litchi chinensis* Sonn.) is one of the most important sub-tropical fruit indigenous to Southern China particularly the provinces of Kwangtung and Fukien. It is highly specific to climate and soil requirement and probably due to which the cultivation of litchi is restricted to the few countries in the World. Depending on the stage of bearing, the entire life period of litchi plants can be grouped into five different stages viz. young non-bearing plants (0-3 years age), Young bearing plants (3-10 years age), Junior-adult bearing plants (10-20 years age), senior adult bearing plants (>20 years age) (Rai *et al*, 2002). During the Young bearing stage of the plants, the

management should be aimed to balance both vegetative and reproductive growth. During Senior-adult bearing stage of the plant, tree reaches to its full yield potential and main aim orchard management of such orchard is to produce maximum yield with maximum feeding.

Appropriate nutrient management strategies including quantity and quality of fertilizer and method of nutrient application holds the key for obtaining higher yield of quality fruits. A proper knowledge of root distribution pattern is important for standardization of methods of fertilizer application in litchi. A meager number of research work have been undertaken to study root distribution pattern in litchi (Menzel *et al*, 1990; Roy *et al*. 1987;

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Huang, 2002). Variation in root distribution pattern of litchi have been reported in case of plants growing under different soil conditions (Menzel *et al.*, 1990). Till date no information has been generated on pattern of root distribution of litchi plants growing under the alfisols of eastern plateau region which is emerging as a potential litchi growing area for early litchi production. The region is characterized by acidic soil (pH 4.5-5.5) with deficiency of phosphorus, zinc and boron in the soil. Keeping this in view, an investigation was undertaken to study the pattern of root distribution in Young bearing and Senior-adult bearing plants of litchi cv. Shahi growing under alfisols of eastern plateau and hill region.

## Materials and Methods

The investigations were carried out at ICAR Research Complex for Eastern region, Research Centre, Plandu, Ranchi, Jharkhand during 2011 and 2012. The soil of the experimental site was Alfisol having sandyloam texture with pH 5.9, organic carbon 0.5%, available N 42 kg/ha, available (Bray I) P 3.2 kg/ha and available K 110kg/ha (Rai *et al.*, 2002). Litchi plants (cv. Shahi) of age more than 25 years were used for studying the root distribution pattern in senior adult bearing plants whereas for studying root distribution pattern in young bearing plants, litchi plants of age 8-10 years were used. For collecting root samples, trenches of 30 cm width were excavated in North-South direction of the plants starting from the base of the tree trunk. Root samples were collected inserting a core sampler (diameter 6.25 cm) vertically downwards just adjacent to one wall of the trench. Root samples were collected from three different depths of soil (0-30 cm, 30-60 cm and 60-90 cm) at distances of 50 cm, 100cm, 150 cm, 200 cm, 250 cm, 300 cm, 350 cm, 450 cm from trunk in both North and South directions in case of senior adult bearing plants and at distances of 50cm, 100cm, 150 cm, 200 cm, 250 cm, 300 cm from trunk in both North and South directions. During both the years the trenches were excavated at same positions and root samples were collected from same positions. The collected samples were washed through sieve to separate the roots from the soil particles. After air drying, the root samples were separated into different grades under laboratory conditions based on root diameter viz. Grade-1 (diameter <1mm), Grade-2 (diameter 1-3 mm), Grade-3 (diameter 3-5 mm), Grade-4 (diameter >5mm) and root

biomass was measured. Hence, the root weight for each sample indicated total root weight per 3683 cc volume of soil. The root sampling was done from 10 plants under each age group and one plant was considered as one replication.

For better interpretation of results, parameters like per cent of total root weight, root under each grade as per cent of total weight under respective grades were derived. For analysis of variance, the data on root weight and 'as % of total root weight' was analyzed in a split-split-plot design and data on 'root under each grade as per cent of total weight under respective grades' were analyzed in a split plot design.

## Results and Discussion

### Root content in south and north aspect of tree

In case of senior adult bearing plants, during both the years, the total root weight in south aspect of tree was recorded to be higher than that in case of north aspect of tree (82.3g and 72.09g in South and north aspect of tree, respectively in 2011 and 66.1g and 60.4g in South and north aspect of tree, respectively in 2012). In case of young bearing plants, during 2011, the total root weight in south aspect of tree was recorded to be higher than that in case of north aspect of tree (28.32g and 26.64 g in South and north aspect of tree, respectively). However, during 2012, the total root weight in both the aspects of the plant was recorded to be same.

### Pattern of root distribution

#### A. root weight

##### Senior adult bearing plants (> 25 years age)

During 2011, significant differences in root weight could be recorded in case of different grades of roots, distance from trunk and interaction between grades of roots x distance from trunk (table 1) whereas in case of 2012, significant differences in root weight could be recorded in case of different grades of roots, distance from trunk, soil depth and interaction between grades of roots x distance from trunk in case of south aspect of tree and different grades of roots, distance from trunk and interaction between grades of roots x distance from trunk in case of north aspect of tree (Table 2).

**Table 1.** Pattern of root distribution (weight) in bearing litchi plants (cv. Shahi) of age more than 25 years in the South and north aspect of tree (2011)

| Distance from trunk | South aspect                          |          |          |                                      |          |          |                                      |          |          |                                    |          |          | North aspect                          |          |          |                                      |          |          |                                      |          |          |                                      |          |          |
|---------------------|---------------------------------------|----------|----------|--------------------------------------|----------|----------|--------------------------------------|----------|----------|------------------------------------|----------|----------|---------------------------------------|----------|----------|--------------------------------------|----------|----------|--------------------------------------|----------|----------|--------------------------------------|----------|----------|
|                     | Grade-1 roots (root diameter <1.0 mm) |          |          | Grade-2 roots (root diameter 1-3 mm) |          |          | Grade-3 roots (root diameter 3-5 mm) |          |          | Grade-4 roots (root diameter >5mm) |          |          | Grade-1 roots (root diameter <1.0 mm) |          |          | Grade-2 roots (root diameter 1-3 mm) |          |          | Grade-3 roots (root diameter 3-5 mm) |          |          | Grade-4 roots (root diameter > 5 mm) |          |          |
|                     | 0-30 cm                               | 30-60 cm | 60-90 cm | 0-30 cm                              | 30-60 cm | 60-90 cm | 0-30 cm                              | 30-60 cm | 60-90 cm | 0-30 cm                            | 30-60 cm | 60-90 cm | 0-30 cm                               | 30-60 cm | 60-90 cm | 0-30 cm                              | 30-60 cm | 60-90 cm | 0-30 cm                              | 30-60 cm | 60-90 cm | 0-30 cm                              | 30-60 cm | 60-90 cm |
| 50 cm               | 1.08                                  | 0.6      | 0.5      | 0.8                                  | 0.33     | 0.2      | 1.3                                  | 0.69     | 0.14     | 6.25                               | 5.5      | 3.79     | 0.91                                  | 0.44     | 0.37     | 0.77                                 | 0.22     | 0.24     | 1.07                                 | 0.76     | 0.29     | 4.6                                  | 2.02     | 0.46     |
| 100 cm              | 0.88                                  | 0.36     | 0.35     | 0.85                                 | 0.36     | 0.27     | 0.49                                 | 0.5      | 0.46     | 0.79                               | 4.97     | 2.56     | 0.81                                  | 0.46     | 0.32     | 0.4                                  | 0.26     | 0.51     | 0.77                                 | 0.78     | 0.12     | 0.91                                 | 4.75     | 5.32     |
| 150 cm              | 0.73                                  | 0.45     | 0.32     | 0.76                                 | 0.29     | 0.27     | 0.62                                 | 0.5      | 0.45     | 2.36                               | 2.89     | 0.58     | 0.61                                  | 0.58     | 0.46     | 0.58                                 | 0.22     | 0.28     | 0.62                                 | 0.54     | 0.25     | 0.9                                  | 1.35     | 2.49     |
| 200 cm              | 1.04                                  | 0.55     | 0.4      | 0.62                                 | 0.36     | 0.34     | 0.75                                 | 0.73     | 0.26     | 1.81                               | 3.59     | 2.75     | 0.86                                  | 0.69     | 0.37     | 0.58                                 | 0.37     | 0.27     | 0.63                                 | 0.84     | 0.13     | 0.57                                 | 5.92     | 3.76     |
| 250 cm              | 0.92                                  | 0.64     | 0.49     | 0.69                                 | 0.29     | 0.25     | 0.7                                  | 0.34     | 0.16     | 0.69                               | 0.55     | 1.62     | 0.84                                  | 0.5      | 0.36     | 0.39                                 | 0.18     | 0.33     | 0.57                                 | 0.44     | 0.15     | 0.82                                 | 0.72     | 1.07     |
| 300 cm              | 0.85                                  | 0.62     | 0.32     | 0.52                                 | 0.42     | 0.14     | 0.29                                 | 0.11     | 0.17     | 0.64                               | 0.44     | 1.18     | 0.58                                  | 0.34     | 0.25     | 0.45                                 | 0.3      | 0.06     | 0.36                                 | 0.4      | 0.17     | 0.78                                 | 1.27     | 0.08     |
| 350 cm              | 0.77                                  | 0.34     | 0.22     | 0.47                                 | 0.2      | 0.21     | 0.43                                 | 0.64     | 0.73     | 0.93                               | 0.39     | 0.34     | 0.33                                  | 0.29     | 0.15     | 0.36                                 | 0.34     | 0.19     | 0.49                                 | 0.47     | 0.2      | 1.07                                 | 0.73     | 0.68     |
| 400 cm              | 0.37                                  | 0.16     | 0.23     | 0.19                                 | 0.18     | 0.14     | 0.21                                 | 0.37     | 0.15     | 0.31                               | 0.7      | 0.47     | 0.15                                  | 0.1      | 0.08     | 0.16                                 | 0.29     | 0.13     | 0.39                                 | 0.23     | 0.4      | 0.2                                  | 0        | 1.02     |
| 450 cm              | 0.26                                  | 0.18     | 0.06     | 0.2                                  | 0.13     | 0.03     | 0.06                                 | 0.18     | 0        | 0.4                                | 0.79     | 0.01     | 0.04                                  | 0.01     | 0.04     | 0.13                                 | 0.01     | 0.04     | 0.15                                 | 0.09     | 0.05     | 0                                    | 0.09     | 0        |

**Young bearing plants (8-10 years age)**

As evident from table 3, during 2011, significant differences in root weight could be recorded in case of Grade of root, distance from trunk, soil depth and Grade of root x distance from trunk in the south aspect of tree, whereas in the north aspect of tree significant differences were recorded in case of Grade of root, distance from trunk and Grade of root x distance from trunk. During 2012, significant differences in root weight could be recorded in case of Grade of root, distance from trunk, soil depth and Distance from trunk X Soil depth in both aspects of the tree (table 4).

**B. Per cent of total root weight**

In case of pattern of root distribution in terms of % of total root weight in senior adult bearing plants (> 25 years age) during 2011, significant differences could be recorded in case of grades of root, distance from trunk, grades of root x distance from trunk in the south aspect of tree and grades of root, distance from trunk, grades of root x distance from trunk, grades of root x soil depth and grades of root x distance from trunk x soil depth in the north aspect of tree. During the year 2012, the differences in the values of per cent of total root weight were significant in case of grades of root, distance from trunk, soil depth and grades of root x distance from trunk x soil depth in the south aspect of tree and grades of root, distance from trunk, grades of root x distance from trunk and grades of root x soil depth.

In case of Young bearing plants (8-10 years age), during 2011 significant differences in the values were recorded in case of Grade of root, distance from trunk, soil depth, Grade of root X Distance from trunk, distance from trunk X Soil depth, Grade of root X distance from trunk X soil depth in the south aspect of tree, whereas in the north aspect of tree, the values were significant in case of Grade of root, distance from trunk, Root type X Distance from trunk, Grade of root X Soil depth, Grade of root X Distance from trunk X Soil depth. During 2012, significant differences in the values were recorded in case of grade of root, Distance from trunk, soil depth and distance from trunk X Soil depth in both north and south aspect of tree.

In case of senior adult bearing plants, during 2011, in both the aspect of trees, the per cent of

S.Em Root type =0.141, Distance from trunk =0.298, Soil depth =0.149, Root type X Distance from trunk =0.597, Root type X Soil depth =0.299, Distance from trunk X Soil depth =0.449, Root type X Distance from trunk X Soil depth =ns  
 C.D. at 5% Root type =0.298, Distance from trunk =0.585, Root type X Distance from trunk =0.597, Soil depth =NS, Root type X Soil depth = NS, Distance from trunk X Soil depth =NS, Root type X Distance from trunk X Soil depth =NS  
 Root type =0.188, Distance from trunk =0.250, Soil depth =0.150, Root type X Distance from trunk =0.501, Root type X Soil depth =0.300, Distance from trunk X Soil depth =0.0.451, Root type X Distance from trunk X Soil depth =\*\*  
 Root type =0.386, Distance from trunk =0.491, Root type X Distance from trunk =0.983, Soil depth =NS, Root type X Soil depth =NS, Distance from trunk X Soil depth =NS, Root type X Distance from trunk X Soil depth =\*\*

total root weight of Grade-4 roots was significantly higher than other grades of roots (Fig. 1) and significant differences were not recorded among the other root grades. Contrastingly during 2012, a sudden increase in the % of Grade-1 roots and sudden decrease in the % of Grade-4 roots could be recorded in both the aspect of the trees. The sudden change can be attributed to formation of new roots on the roots remaining after pruning of the older roots during the process of excavation of trench in 2007. A similar pattern was also recorded in case of young bearing plants (Fig. 2).

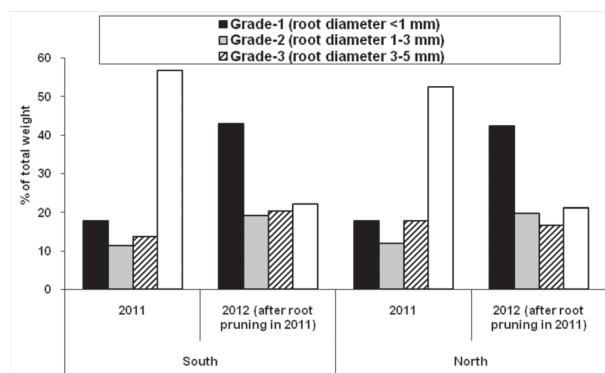


Fig. 1. Pattern of distribution (% of total root wt.) of different grades of roots in senior adult bearing (more than 25 years age) litchi plants of cv. Shahi

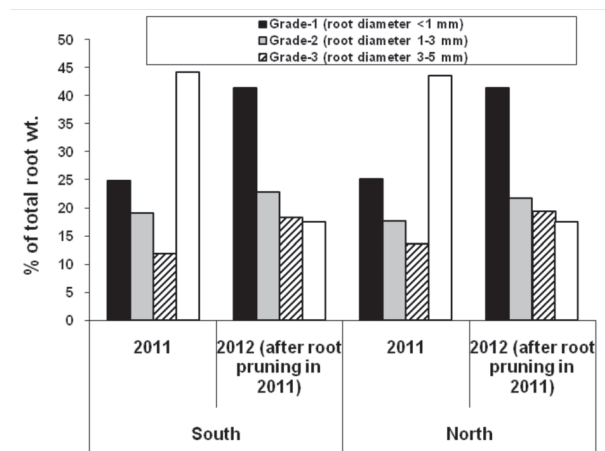


Fig. 2. Pattern of distribution (% of total root wt.) of different grades of roots in young bearing plants (8-10 years age) of litchi cv. Shahi

In case of senior adult bearing plants during 2011, a sudden and significant reduction in the value of per cent of total root weight was recorded starting from a distance of 250 cm (nearly 50% of canopy

Table 2. Pattern of root distribution (weight) in bearing litchi plants (cv. Shahi) of age more than 25 years in the South and north aspect of tree (2012)

| Distance from trunk | South aspect  |       |       |      |                                      |       |       |      |                                      |       |       |      | North aspect   |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                    |       |       |      |      |      |      |      |
|---------------------|---|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--|-------|-------|------|---------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|------------------------------------|-------|-------|------|------|------|------|------|
|                     | Grade-1 roots (root diameter <1.0 mm)   |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5mm)   |       |       |      | Grade-1 roots (root diameter <1.0 mm) |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5mm) |       |       |      |      |      |      |      |
|                     | 0-30  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30   | 30-60 | 60-90 | cm   | 0-30                                  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                               | 30-60 | 60-90 | cm   |      |      |      |      |
| 50 cm               | 1.59  | 1.43  | 0.72  | 0.75 | 0.66                                 | 0.38  | 1.04  | 0.57 | 0.59                                 | 0.57  | 2.18  | 0.71 | 1.04   | 0.87  | 1.11  | 0.74 | 0.52                                  | 0.5   | 0.76  | 0.53 | 0.47                                 | 1.18  | 0.35  | 2.68 | 1.04                                 | 0.87  | 1.11  | 0.74 | 0.52                               | 0.5   | 0.76  | 0.53 | 0.47 | 1.18 | 0.35 | 2.68 |
| 100 cm              | 1.59  | 1.61  | 0.84  | 0.56 | 0.67                                 | 0.44  | 0.42  | 0.5  | 0.28                                 | 1.14  | 0.59  | 0.5  | 1.27   | 1.31  | 1.25  | 0.69 | 0.64                                  | 0.55  | 0.51  | 0.44 | 0.35                                 | 0.23  | 0.13  | 0.7  | 1.27                                 | 1.31  | 1.25  | 0.69 | 0.64                               | 0.55  | 0.51  | 0.44 | 0.35 | 0.23 | 0.13 | 0.7  |
| 150 cm              | 1.04  | 1.52  | 1.1   | 0.39 | 0.46                                 | 0.53  | 0.58  | 0.24 | 0.49                                 | 1.22  | 2.25  | 0    | 0.93   | 1.35  | 1.44  | 0.44 | 0.62                                  | 0.5   | 0.57  | 0.38 | 0.3                                  | 0.26  | 0.21  | 0.84 | 0.93                                 | 1.35  | 1.44  | 0.44 | 0.62                               | 0.5   | 0.57  | 0.38 | 0.3  | 0.26 | 0.21 | 0.84 |
| 200 cm              | 1.13  | 0.91  | 0.74  | 0.52 | 0.4                                  | 0.59  | 0.3   | 0.53 | 0.62                                 | 0.62  | 0.6   | 0.05 | 1.33   | 1.42  | 1.19  | 0.42 | 0.39                                  | 0.6   | 0.2   | 0.28 | 0.58                                 | 0.43  | 0.11  | 0.4  | 1.33                                 | 1.42  | 1.19  | 0.42 | 0.39                               | 0.6   | 0.2   | 0.28 | 0.58 | 0.43 | 0.11 | 0.4  |
| 250 cm              | 1.25  | 1.07  | 0.85  | 0.44 | 0.36                                 | 0.45  | 0.58  | 0.63 | 0.34                                 | 0.23  | 1.04  | 0.25 | 0.93   | 1.3   | 0.89  | 0.36 | 0.46                                  | 0.57  | 0.1   | 0.43 | 0.42                                 | 0.31  | 0.05  | 0.46 | 0.93                                 | 1.3   | 0.89  | 0.36 | 0.46                               | 0.57  | 0.1   | 0.43 | 0.42 | 0.31 | 0.05 | 0.46 |
| 300 cm              | 1.56  | 1.08  | 0.89  | 0.45 | 0.46                                 | 0.25  | 0.23  | 0.24 | 0.14                                 | 0.4   | 0.56  | 0.07 | 1.04   | 1.94  | 0.99  | 0.4  | 0.7                                   | 0.48  | 0.44  | 0.47 | 0.62                                 | 0.96  | 0.13  | 0.21 | 1.04                                 | 1.94  | 0.99  | 0.4  | 0.7                                | 0.48  | 0.44  | 0.47 | 0.62 | 0.96 | 0.13 | 0.21 |
| 350 cm              | 1.02  | 1.14  | 1.06  | 0.43 | 0.53                                 | 0.39  | 0.09  | 0.49 | 0.34                                 | 0.19  | 0.82  | 0.72 | 1.07   | 0.93  | 1.16  | 0.43 | 0.56                                  | 0.32  | 0.17  | 0.27 | 0.46                                 | 0     | 0.16  | 0.98 | 1.07                                 | 0.93  | 1.16  | 0.43 | 0.56                               | 0.32  | 0.17  | 0.27 | 0.46 | 0    | 0.16 | 0.98 |
| 400 cm              | 0.79  | 0.81  | 0.48  | 0.32 | 0.3                                  | 0.36  | 0.19  | 0.35 | 0.2                                  | 0.19  | 0.09  | 0.35 | 0.59   | 0.45  | 0.57  | 0.19 | 0.3                                   | 0.17  | 0.17  | 0.16 | 0.16                                 | 0.77  | 0.57  | 0.23 | 0.59                                 | 0.45  | 0.57  | 0.19 | 0.3                                | 0.17  | 0.17  | 0.16 | 0.16 | 0.77 | 0.57 | 0.23 |
| 450 cm              | 0.69  | 0.39  | 0.61  | 0.22 | 0.2                                  | 0.31  | 0     | 0.2  | 0.11                                 | 0.15  | 0.13  | 0.62 | 0.14   | 0.1   | 0.17  | 0.02 | 0.05                                  | 0.14  | 0.02  | 0.15 | 0.13                                 | 0     | 0     | 0    | 0.14                                 | 0.1   | 0.17  | 0.02 | 0.05                               | 0.14  | 0.02  | 0.15 | 0.13 | 0    | 0    | 0    |
| S.Em                | Root type =0.165, Distance from trunk =0.129, Soil depth =0.072,  |       |       |      |                                      |       |       |      |                                      |       |       |      | Root type =0.127, Distance from trunk =0.135, Soil depth =0.075,   |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                    |       |       |      |      |      |      |      |
|                     | Root type X Distance from trunk =0.259, Root type X Soil depth =0.145, Distance from trunk X Soil depth =0.217, Root type X Distance from trunk X Soil depth =ns  |       |       |      |                                      |       |       |      |                                      |       |       |      | Root type X Distance from trunk =0.270, Root type X Soil depth =0.150, Distance from trunk X Soil depth =0.225, Root type X Distance from trunk X Soil depth =ns |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                    |       |       |      |      |      |      |      |
| C.D. at 5%          | Root type =0.339, Distance from trunk =0.253, Root type X Distance from trunk =0.507, Soil depth =0.142, Root type X Soil depth =NS, Distance from trunk X Soil depth =NS, Root type X Distance from trunk X Soil depth =NS |       |       |      |                                      |       |       |      |                                      |       |       |      | Root type =0.261, Distance from trunk =0.265, Root type X Distance from trunk X Soil depth =NS, Root type X Distance from trunk X Soil depth =NS                 |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                    |       |       |      |      |      |      |      |

**Table 3.** Pattern of root distribution (weight) in young bearing litchi plants (cv. Shahi) of age 8-10 years in the South and north aspect of tree (2011)

| Distance from trunk | South aspect                          |       |       |      |                                      |       |       |      |                                      |       |       |      | North aspect                       |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                    |       |       |     |
|---------------------|---------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|------------------------------------|-------|-------|------|---------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|------------------------------------|-------|-------|-----|
|                     | Grade-1 roots (root diameter <1.0 mm) |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5mm) |       |       |      | Grade-1 roots (root diameter <1.0 mm) |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5mm) |       |       |     |
|                     | 0-30                                  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                               | 30-60 | 60-90 | cm   | 0-30                                  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                               | 30-60 | 60-90 | cm  |
| 50 cm               | 0.69                                  | 0.42  | 0.19  | 0.4  | 0.43                                 | 0.54  | 0.61  | 0.35 | 0.08                                 | 0.35  | 0.08  | 3.55 | 2.94                               | 1.35  | 0.51  | 0.27 | 0.24                                  | 0.6   | 0.23  | 0.14 | 0.7                                  | 0.2   | 0.1   | 1.71 | 2.09                                 | 1.16  | 0.61  | 0.5  | 0.37                               | 0.76  | 0.29  | 0.3 |
| 100 cm              | 0.61                                  | 0.5   | 0.37  | 0.76 | 0.43                                 | 0.54  | 0.61  | 0.35 | 0.08                                 | 0.35  | 0.08  | 3.55 | 2.94                               | 1.35  | 0.8   | 0.59 | 0.48                                  | 0.47  | 0.3   | 0.35 | 0.5                                  | 0.28  | 0.37  | 0.24 | 1.05                                 | 1.15  | 0.69  | 0.48 | 0.35                               | 0.37  | 0.24  |     |
| 150 cm              | 0.69                                  | 0.48  | 0.35  | 0.42 | 0.3                                  | 0.17  | 0.39  | 0.15 | 0.26                                 | 0.15  | 0.08  | 0.4  | 0.52                               | 0.35  | 0.52  | 0.35 | 0.38                                  | 0.38  | 0.26  | 0.31 | 0.2                                  | 0.52  | 0.18  | 0.57 | 0.58                                 | 1.63  | 0.47  | 0.59 | 0.48                               | 0.38  | 0.26  |     |
| 200 cm              | 0.65                                  | 0.31  | 0.29  | 0.42 | 0.18                                 | 0.18  | 0.16  | 0.18 | 0.05                                 | 0.09  | 0.27  | 0.47 | 0.39                               | 0.26  | 0.47  | 0.39 | 0.26                                  | 0.24  | 0.2   | 0.24 | 0.2                                  | 0     | 0.12  | 0.61 | 0.46                                 | 1.55  | 0.27  | 0.27 | 0.22                               | 0.16  | 0.19  |     |
| 250 cm              | 0.27                                  | 0.22  | 0.16  | 0.19 | 0.22                                 | 0.11  | 0.19  | 0.12 | 0.06                                 | 0.31  | 0.44  | 0.14 | 0.2                                | 0.14  | 0.2   | 0.14 | 0.14                                  | 0.08  | 0.31  | 0.08 | 0.01                                 | 0.16  | 0.06  | 0.08 | 0.24                                 | 0.17  | 0.03  | 0.03 | 0.04                               | 0.03  | 0.04  |     |
| 300 cm              | 0.03                                  | 0.02  | 0.03  | 0.04 | 0.03                                 | 0.04  | 0     | 0    | 0                                    | 0     | 0     | 0.05 | 0                                  | 0.05  | 0     | 0    | 0                                     | 0     | 0     | 0    | 0                                    | 0     | 0     | 0    | 0                                    | 0     | 0     | 0    | 0                                  | 0     | 0     |     |

S.Em Root type =0.122, Distance from trunk =0.132, Soil depth =0.073, Root type X Distance from trunk =0.264, Root type X Soil depth =0.147, Distance from trunk X Soil depth =0.180, Root type X Distance from trunk X Soil depth =ns  
 Root type =0.250, Distance from trunk =0.259, Root type X Distance from trunk =0.264, Soil depth =0.144, Root type X Soil depth =NS, Distance from trunk X Soil depth =NS, Root type X Distance from trunk X Soil depth =NS

Pattern of root distribution (weight) in young bearing litchi plants (cv. Shahi) of age 8-10 years in the south and north aspect of tree (2012)

| Distance from trunk | South aspect                          |       |       |      |                                      |       |       |      |                                      |       |       |      | North aspect                       |       |       |      |                                       |       |       |      |                                      |       |       |      |                                      |       |       |      |                                     |       |       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|---------------------|---------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|------------------------------------|-------|-------|------|---------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|--------------------------------------|-------|-------|------|-------------------------------------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                     | Grade-1 roots (root diameter <1.0 mm) |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5mm) |       |       |      | Grade-1 roots (root diameter <1.0 mm) |       |       |      | Grade-2 roots (root diameter 1-3 mm) |       |       |      | Grade-3 roots (root diameter 3-5 mm) |       |       |      | Grade-4 roots (root diameter >5 mm) |       |       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                     | 0-30                                  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                               | 30-60 | 60-90 | cm   | 0-30                                  | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                 | 30-60 | 60-90 | cm   | 0-30                                | 30-60 | 60-90 | cm   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 50 cm               | 1.11                                  | 0.89  | 0.54  | 0.76 | 0.62                                 | 0.27  | 0.77  | 0.4  | 0.32                                 | 0.74  | 0.53  | 0.28 | 0.87                               | 0.77  | 0.39  | 0.71 | 0.59                                  | 0.26  | 0.78  | 0.41 | 0.4                                  | 0.71  | 0.58  | 0.56 | 100 cm                               | 0.91  | 0.76  | 0.53 | 0.7                                 | 0.54  | 0.36  | 0.45 | 0.54 | 0.46 | 0.34 | 0.28 | 0.38 | 0.85 | 1.14 | 0.75 | 0.48 | 0.3  | 0.42 | 0.56 | 0.37 | 0.3  | 1.2  | 0.2  |      |
| 150 cm              | 0.66                                  | 0.72  | 0.59  | 0.35 | 0.43                                 | 0.33  | 0.24  | 0.26 | 0.39                                 | 0.25  | 0.69  | 0.07 | 0.64                               | 0.8   | 0.51  | 0.33 | 0.43                                  | 0.39  | 0.16  | 0.44 | 0.23                                 | 0.21  | 0.67  | 0.2  | 200 cm                               | 0.57  | 0.99  | 0.45 | 0.27                                | 0.37  | 0.35  | 0.27 | 0.25 | 0.19 | 0.5  | 0.39 | 0.21 | 0.35 | 0.52 | 0.51 | 0.19 | 0.26 | 0.32 | 0.11 | 0.37 | 0.33 | 0.08 | 0.19 | 0.07 |
| 250 cm              | 0.4                                   | 0.44  | 0.51  | 0.25 | 0.21                                 | 0.23  | 0.07  | 0.26 | 0.23                                 | 0     | 0.18  | 0    | 1.02                               | 0.5   | 0.4   | 0.23 | 0.33                                  | 0.12  | 0     | 0.16 | 0.31                                 | 0.19  | 0.3   | 0.03 | 300 cm                               | 0.28  | 0.19  | 0.43 | 0.08                                | 0.1   | 0.17  | 0.04 | 0.08 | 0.27 | 0    | 0.16 | 0    | 0.25 | 0.25 | 0.17 | 0.09 | 0.06 | 0.11 | 0.09 | 0.14 | 0    | 0    | 0    | 0.66 |

S.Em Root type =0.046, Distance from trunk =0.058, Soil depth =0.041, Root type X Distance from trunk =0.117, Root type X Soil depth =0.083, Distance from trunk X Soil depth =0.102, Root type X Distance from trunk X Soil depth =ns  
 Root type =0.095, Distance from trunk =0.114, Root type X Distance from trunk =ns, Soil depth =0.081, Root type X Soil depth =NS, Distance from trunk X Soil depth =0.200, Root type X Distance from trunk X Soil depth =NS

spread) from the trunk at both aspects of the tree (Fig.3) which continued to decrease till 450 cm (boundary of canopy spread of tree). During 2012, a marked plateauing of the values of per cent of total root weight at different distances from the trunk could be observed particularly in the region of 250 cm to 300 cm from the trunk at both the aspects of tree. This was attributed to increased production of root biomass in the region between 250-350 cm from the trunk after pruning of the roots during the process of excavation of trench during 2011.

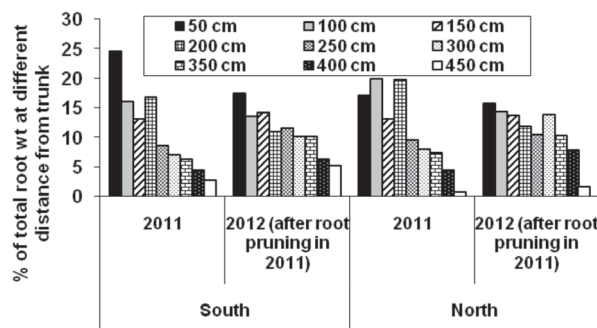


Fig. 3. Pattern of root distribution (% of total root wt.) at different distances from trunk in senior adult bearing plants (<25 years age) of litchi cv. Shahi

In case of young bearing plants, during 2011, gradual and significant reduction in the root content as per cent of total root weight could be recorded till 150 cm distance in the south aspect of the plants (Fig 4.). The differences in the values were non-significant at 150cm, 200 cm, 250 cm distance from the trunk. In the north aspect of the plants, significant reduction in the value could be recorded after a distance of 200 cm from the trunk. During 2012, a

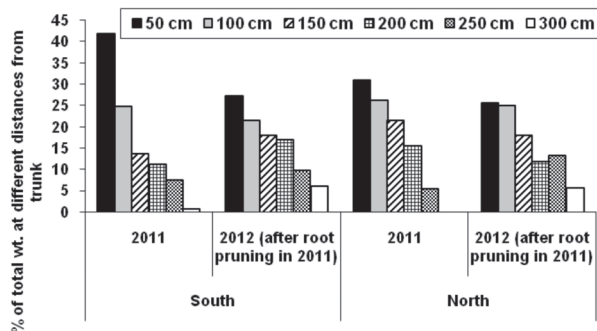


Fig. 4. Pattern of root distribution (% of total root wt.) at different distances from trunk in young bearing (age 8-10 years) plants of litchi cv. Shahi

marked increase in the content of root (% of total root weight) could be recorded at a distance after 150 cm from the trunk in case of south aspect of tree whereas in north aspect of tree, marked increase in the value could be recorded only at 250 cm and 300 cm from trunk. The increase in the value can again be attributed to formation of new roots and thickening of existing roots after root pruning during 2011. The trend also indicated a differential pattern of root responses to pruning at different aspects of tree.

During both the years, significant differences in % of total root weight could not be recorded at different depths at both the aspects of trees in case of senior adult bearing trees. However, in case of young bearing trees, significant difference in the content of root (% of total root weight) could be recorded in both the aspects of trees during 2011 and 2012 except in case of north aspect of tree during 2011. A marked increase in the value at depth of 30-60 cm depth in the both the aspects of tree (Fig 5) indicated greater rate of formation of new roots and root thickening at 30-60 cm depth following root pruning during 2011. However, Roy *et al.* (1987) had reported maximum density of feeder root at a depth

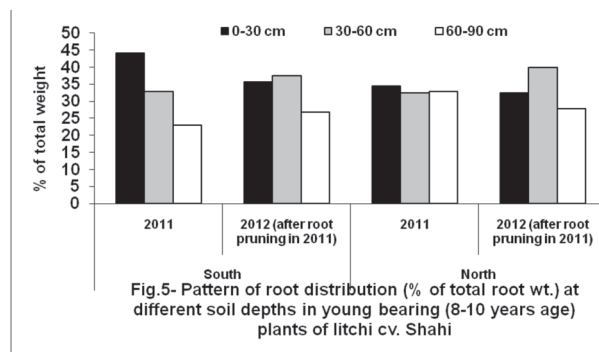


Fig. 5. Pattern of root distribution (% of total root wt.) at different soil depths in young bearing (8-10 years age) plants of litchi cv. Shahi

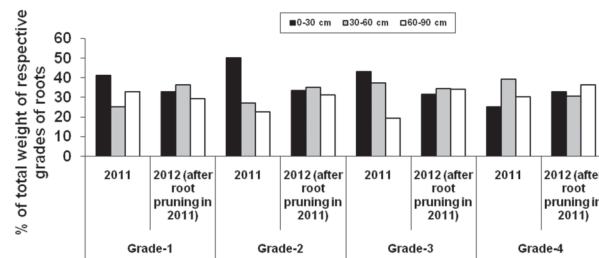


Fig. 6. Pattern of distribution of different grades of roots (% of total weight of respective grades of roots) at different soil depths in senior adult bearing plants (>25 years) of litchi cv. Shahi

of 0-30 cm in plants growing under West Bengal conditions. Menzel *et al.* (1990) had indicated difficulties in separating the effects of depth per se from those of soil properties in reducing root growth. Hence, the difference in the rooting pattern with respect to soil depth in the present study can be attributed to significant difference in the soil properties of the two regions.

#### **Per cent of different grades out of total weight of respective grades**

##### **Senior adult bearing plants (> 25 years age)**

With respect to pattern of distribution of different grades of roots in terms of per cent out of total weight of respective grades of roots, during 2011, significant differences in values of distance from trunk, soil depth, distance from trunk x soil depth could be recorded in case of both the aspects of Grade-1 and Grade-2 roots. In case of Grade-3 roots, the differences in values were significant in case of distance from trunk and soil depth. Significant differences in Grade-4 roots could only be observed in case of distance from trunk. During 2012, significant differences could be recorded among the values distances from the trunk only in case of Grade-2 and Grade-3 roots in both the aspects of tree whereas differences in values were non-significant in case of Grade-4 roots. In case of Grade-1 roots, significant differences in the values at different depths could be recorded in case of south aspect of tree whereas in case of north aspect of tree, the values were significantly different in case of distances from the trunk.

As evident in Fig. 6, a higher average value of per cent of total weight of respective grades was recorded in the upper 0-30 cm layer of soil in case of Grade-1, Grade-2 and Grade-3 roots during 2011. However, during 2012, a marked increase in the value in the 30-60 cm layer could be recorded in case of Grade-1 and Grade-2 roots. This can be attributed to a higher rate of production of new roots at 30-60 cm layer soil due to root pruning during excavation of trench during 2011.

##### **Young bearing plants (8-10 years age)**

During 2011, significant differences in values of distance from trunk and soil depth could be recorded in case of both the aspects of Grade-1 and Grade-2 roots. In case of Grade-3 roots, the differences in values were significant in case of distance from trunk, soil depth and their interaction. Significant differences in Grade-4 roots could only be observed in case of distance from trunk. During 2012, signifi-

cant differences in the values in case of distances from trunk, soil depth and their interaction could be recorded in case of Grade-1 and Grade-2 roots in both the aspects of trees whereas in case of Grade-3 roots, the differences in values at different depths were non-significant. In both the aspects of the plants, the differences among the values were non-significant in case of Grade-4 roots.

With respect to the average values of 'per cent of total weight of respective grades of roots' at different distances from the trunk, a higher content of roots was recorded near the trunk viz. 50 cm and 100 cm distance from the trunk during both the years. However, a marked increase in the content of root of all the all the grades could be recorded during 2012 over that in case of 2011 at distance of 250 cm and 300 cm from the trunk. This indicated a higher rate of formation of new roots or root thickening at this zone followed by root pruning during 2011.

Hence, the present investigations clearly indicated presence of higher amount of finer roots at a distance between 250-350 cm from the trunk in case of senior adult bearing trees and at a distance of 250-300 cm from the trunk in case of young bearing trees. Fertilizer placement in litchi plants growing under alfisols of eastern plateau region should be made in this zone for increased nutrient uptake.

**Declaration of conflict of interest:** The author declare that he has no conflict of interest.

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