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# Application of 3-4-5 Rule in Agriculture: A Review

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author KP designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author PPM managed the analyses of the study and correction in language. Authors CJ and DSK managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

Layout is a precious component in Agriculture. Layout has pivotal and unique role not only in Agriculture sector but also applicable for manufacturing and construction sector. In agriculture, starting from field bond construction, irrigation channel preparation, dam construction, orchard development, farm pond making to greenhouse construction, layout is utmost important. Modern Agriculture based on Precision Farming where layout plan is important consideration without which, it is difficult to manage different components precisely. Pythagorean Theorem is the meticulous way to obtain accuracy in measure of layout. Otherwise, it endorses serious drawback in modern concept farming as it is more complex than age old traditional farming. At present day, ignorance among the farmers, students, research persons, technical personnel and others, create a great limitation of this formula to be used in agriculture sector. Hence, this article is documented about important practical uses of 3-4-5 rule in various aspects of Agriculture.

*Keywords: 3-4-5; right angle triangle; orchard; layout; Euclidean.*

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## 1. INTRODUCTION

The 3-4-5 rule popularly known as Pythagorean Theorem (American English) or Pythagoras' theorem (British English) named after the Greek mathematician Pythagoras [1]. It represents a relation in Euclidean geometry among the three sides of a right triangle. The Theorem state that, in any right triangle, the square of the hypotenuse is equal to the sum of the squares of Perpendicular and Base [2]. If we let *h* be the length of the hypotenuse and *p* and *b* be the lengths of the other two sides i.e. Perpendicular and Base, the theorem can be expressed in ABC right angle (Fig. 1) as the following equation:

$$h^2 = p^2 + b^2$$

The 3-4-5 method can also be the 6-8-10 or the 9-12-15 method, since the proportions are the same. Any standard of length measurement can be used like inches, centimetres, feet, meters or kilometres [1].

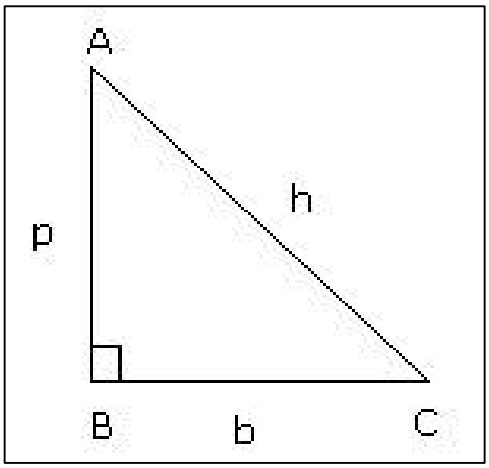


**Fig. 1. ABC right angle**

## 2. APPLICATION OF 3-4-5 IN AGRICULTURE

Laying out a square and rectangular plot from an uneven land (Fig. 2) requires a straight Baseline first [3]. Usually, the Baseline is an imaginary line drawn parallel to a fence or roadway or building side (Fig. 3). Then, lines at right angles to the baseline are drawn at both ends of the plot or one or two places in the middle. A simple and common principle to develop these angles is to use the 3-4-5 rule (Pythagoras theorem). In a conventional way, three ropes whose lengths are in 3:4:5 proportions are taken. The rope measured 4m in length is kept along the baseline, then the 3 m rope is placed at approximately a right angle and finally, the both end of 3m rope and 4m rope is joint with close the 5 m rope to form a triangle. Then, final adjustment is done by movement of the 3 m rope in either direction so that it just touches the end of the 5 m rope such that the 3 m rope forms right angle to the baseline (4 m rope). The ropes are fixed after accurate measurement with the help of wooden pegs. After formation of right angle triangle, 3m rope and 4m rope are extended to desired length of the field. Similar procedure is followed at four corners of the field to make it into a perfect square and rectangular (Figs. 4 to 7).

Some of the important application of 3-4-5 rule in the field of agriculture are discussed below;

1. Designing of Research plot
2. Establishment of orchards
3. Determining plant population
4. Construction of Greenhouse
5. Establishment of Nursery
6. Construction of bonds and irrigation channel
7. Crop cutting experiment and yield estimation
8. Determining Euclidean distance

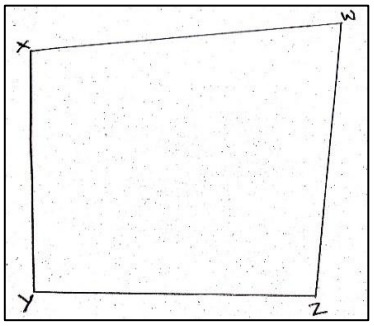


Fig. 2. WXYZ uneven field

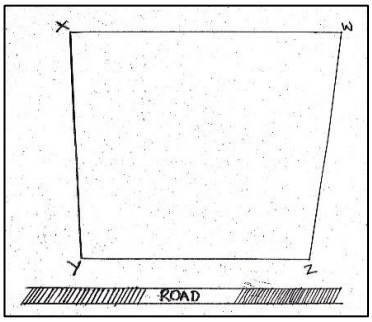


Fig. 3. Road as Baseline

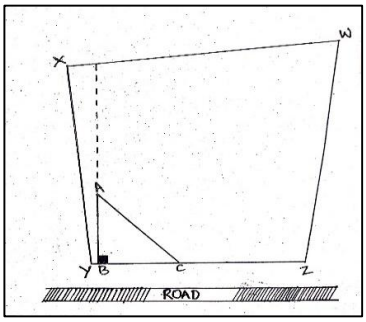


Fig. 4. Use of ABC ◺ at 1st corner of field

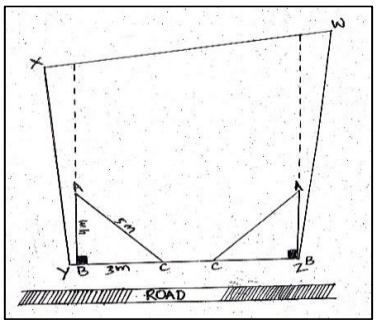


Fig. 5. Use of ABC ◺ at 2nd corner of field

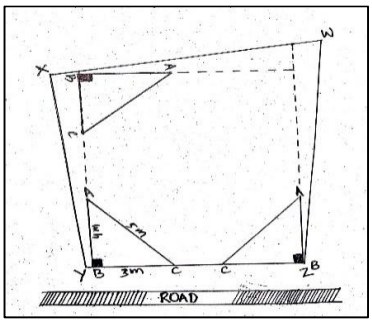


Fig. 6. Use of ABC ◺ at 3rd corner of field

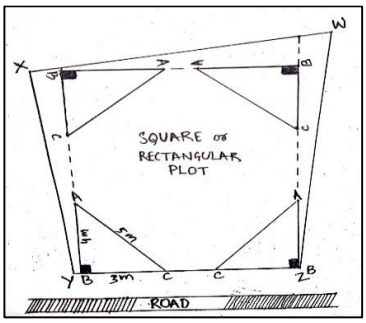


Fig. 7. Use of ABC ◺ at 4th corner of field with desired plot

**Figs. 2 to 7. Application of 3-4-5 rule to get a square or rectangular plot out of WXYZ uneven field**

## 2.1 Designing of Research Plot

Generally, square or rectangular research plots are used in agricultural experiment in order to minimize the experimental error in research findings. To manage an uneven and irregular filed into a square or rectangular is not an easy task, resulted, many unnecessary variations are created within the replications in research plots for which the experiment may fail. But, with the use of Pythagorean Theorem it is easy and accurate way to form square and rectangular fields and plots [4]. Therefore, the principle of Pythagoras Theorem is used to prepare layout of the experiment with a baseline which is to be fixed mostly parallel to the bund. Then, right angle to this baseline, another line is to be fixed and for having a right angle.

## 2.2 Establishment of Orchard

Developing of an orchard is a long term investment which requires a very well thought planning. Any mistake or error during establishment of orchard attracts huge financial loss in future. The selection of proper location and site, layout, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production. Among these, layout of an orchard is a critical factor of consideration. A proper layout decides the use of different planting system like, Square system, Rectangular system, Hexagonal, Quincunx and Triangular, also maximize the plant population, land and other resources uses per unit area, ensures proper development of the trees and convenience in orchard cultural practices, reduces undesirable competition between the plants, waste of land, etc. [5]. Choosing a wrong layout pays a serious failure in establishment of orchard. Therefore, it is pertinent to recommend Pythagorean Theorem strictly in planning of layout in orchard making at very beginning phase of establishment of orchard. In High Density Planting (HDP) of mango a close spacing of 2.5 m is adopted in both row to row and plant to plant direction. In this case, Pythagorean Theorem is used to maintain a high accuracy in row to row

and plant to plant spacing and to form a perfect square orchard. This avoid unnecessary overcrowding of plants due to wrong geometry.

## 2.3 Determining Plant Population

Different planting system such as Square system, Rectangular system, Hexagonal, Quincunx and Triangular are adopted in orchard planting and vegetables cultivation [5]. These planting systems are prepared by following a simple and basic principle i.e. Pythagorean Theorem. This helps greatly in determining the plant population or number of seed or seedlings requirement in Agriculture. Without which it is very much difficult to predict the plant population or number of seeds or seedling requirement which may endorse in short fall or excess in seed or seedlings arrangement for sowing and transplanting. In both the case, farmers face low crop productivity or increase in cost of crop cultivation. For example, if farmers has to establish a papaya orchard in one hectare of land then he has to procure or raise 2500 number of papaya seedlings in order to accommodate these in one hectare of land with recommended plant spacing of 2m in both row to row and plant to plant direction [5].

## 2.4 Construction of Greenhouse

The greenhouses are the structure made up of iron pole and pipe with polythene as a cladding material which provides suitable environments and protect the plants from biotic and abiotic stresses. These structures are to be designed for necessary safety, serviceability, general structural integrity and suitability. The structure should be able to take all the necessary dead, live, wind and snow loads. The foundation, columns and trusses are to be designed accordingly. So any mistake in structural design leads to great economic loss to farmers as these are most vulnerable to heavy winds, floods or cyclone. Generally, a perfect square or rectangular layout is always mandatory for greenhouse construction. Therefore, Pythagorean Theorem is definitely followed. The size of greenhouse are varies in sizes ranging from 1000 to 10,000 $m^2$ depending on the requirement and accordingly the cost varies like; low cost polyhouse ranging from Rs.250-400/ $m^2$, medium cost ranging from Rs.500-1000/ m2 and high cost polyhouse Rs.1000-2000/ $m^2$ [6]. So, the theorem is taken into consideration in order to decide and construct a perfect dimension of protected structure which avoid economic loss to farmers.

## 2.5 Establishment of Nursery

A model nursery is always having all the components arranged in a perfect orientation. Permanent Nursery is a long term investment which has different permanent structures like poly house, shade net house, hardening off unit, tissue culture unit, roads, nursery beds, micro-irrigation systems, stores etc. So, any mistake in designing in its layout and orientation attracts heavy financial loss and difficult to rectify. Therefore, for a proper layout plan of square or rectangular is made first with the 3-4-5 rule in order to maximize the land and resources uses [3] and [5].

## 2.6 Construction of Bonds and Irrigation Channel

Bonds and irrigation channels are important component in Agriculture for demarcation, irrigation, reduce surface run off of water, checks soil erosion etc. But this acquires vast part of land, if not constructed with proper plan and layout. For which, also the 3-4-5 rule is also applicable to make bonds and channels straight and to increase use efficiency of land use and water resources. [7] adopted Pythagorean Theorem for designing and construction of demo-fields to increase rice production, including the introduction of New Rice for Africa (NERICA) cultivars. NERICAs are interspecific hybrids between *Oryza sativa* and *Oryza glaberrima* developed by the Africa Rice Centre [8].

## 2.7 Crop Cutting Experiment and Yield Estimation

Crop cutting experiment is an important technique for estimation of yields in many crop plants. In this technique, a certain size of plot is selected for harvesting of crop for which the principle of Pythagorean Theorem is used and further yield estimation is done [9]. Farmers and extension personnel are trained to use this principle with the help of measured ropes or wooden and iron frames. [10] investigated genotype-environment interaction (GEI) by using AMMI Stability Value (ASV) which is essential to quantify and rank genotypes in terms of yield stability where, additive main effects and multiplicative interaction (AMMI) model is fail to do so. The ASV is the distance from zero in a two-dimensional scattergram and the distance from zero is then determined using the Pythagorean Theorem. According, to ASV method, a genotype is considered as most stable with the lowest ASV score.

### 2.8 Determining Euclidean Distance

Euclidean Median or Mean Centre or Median Centre is an important statistical technique in Spatial data analysis. In a set of data, mean is a consideration in order to measure the central tendency. If the concept is applied to location point data in two dimensions (X and Y coordinates), the average location is called the Euclidean Median. In a location coordinate system, deviations are considered as the distances between points. One standard procedure for measuring distances is based on straight line between two points which is called the Euclidean distance. So, the Euclidean distance is well defined by Pythagorean Theorem and determined by using deviation and mean center between two points. This distance is used for pointing out administrative boundaries, land use, soil map, village location etc. [11]

## 3. CONCLUSION

It is inferred that the Pythagorean Theorem which has multiple application in space, manufacturing and building sectors, also has many practical uses in Agriculture sectors. A systematic research on this theorem and its impact, has been initiated by many researcher in field of agriculture which is required to follow up. Hence, this article is opined to help the agriculture students, researchers, farmers, agri-entrepreneur to take as reference for its application thereof.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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