The Pharma Innovation Journal 2022; 11(12): 1009-1017

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 1009-1017

www.thepharmajournal.com
Received: 12-09-2022
Accepted: 13-10-2022

Dr. DV Nimbalkar
Business Manager, ICAR, CIRCOT, Mumbai, Maharashtra, India

Dr. SM Nalawade
Associate Professor & Head, Department of Farm Machinery and Power Engineering, Dr. A.S.C.A.E.&T., MPKV, Rahuri, Maharashtra, India

AS Kale
Assistant Professor, Department of Agronomy, College of Agriculture, Sonai, Maharashtra, India

Corresponding Author:
Dr. DV Nimbalkar
Business Manager, ICAR, CIRCOT, Mumbai, Maharashtra, India

A review paper on development and standardization of metering mechanism for automatic turmeric planter

Dr. DV Nimbalkar, Dr. SM Nalawade and AS Kale

Abstract
Turmeric planting is a laborious and time-consuming field operation when performed manually. The semi-automatic Turmeric planters are operating due to limitations on manual feeding rates of finger which vary with respect to work duration and skill of the operator. Automation in the field of Turmeric planters has provided opportunities for savings in labour and time required for planting operation in open field and controlled environmental structures. The advent and recent advances in planting technologies suggest ample scope of working on automated Finger pickup and drop mechanisms. Use of finger pickup mechanism in automatic planters can repeatedly extract single finger automatically from the finger hopper with the help of a forks and drop at predefined location. In general, these systems comprise either a machine vision system for extracting the finger; a finger removal device with ejector; or a pick-up system, feeding system and a planting system. Such automated systems have helped ease the planting operation and efficient planting by maintaining the accuracy, precision and effectiveness in planting finger with minimum human intervention. This study highlights the research gaps and developments in smart planting technologies used in the field of Turmeric cultivation.

Keywords: Automation in agriculture, smart farming, turmeric planter, automatic planter, finger planter

Introduction
Turmeric is considered as one of the important food items of Indian diet without which any meal is incomplete. Due to this need, the cultivation and production of Turmeric are increasing day-by-day. India produces nearly 94% of the total turmeric production in the world and it enjoys nearly 50% of the global market.

Area Production and Productivity
It is widely cultivated in the countries such as India, Pakistan, Bangladesh and China, which form the important producing countries in the world. Turmeric was cultivated over an area of 1, 93,395 ha in India with a production of 10, 51160 tons during 2016-17. India is the leading producer and supplier of turmeric in the world. During 2000-01 the export of turmeric was 44,627 tones and was increased to 51500 tones in 2006-07. However, export earnings have increased from Rs. 11558 Lakhs in 2000-01 to Rs.16480 Lakhs in 2006-07. The UAE, Bangladesh, Sri Lanka, USA and Japan are the major markets for Indian turmeric. India enjoys a monopoly position with a share of 90% in the international trade for turmeric. (Sakamma 2009). Maharashtra and Tamil Nadu were second and third in the ranking 2018 year. Volume of turmeric produced across India in financial year 2018, by state Telangana 294.56, Maharashtra 190.09, Tamil Nadu 116, Gujarat 78.91 (in 1,000 metric tons), (source APEDA 2018 data).

Utility of turmeric and its nutritive Value
Turmeric is a flowering plant, *Curcuma longa* of the ginger family, the roots of which are used in cooking. The plant is a perennial, rhizomatous, herbaceous plant native to the Indian subcontinent and Southeast Asia, that requires temperatures between 20 and 30 °C, (68 and 86 °F) and a considerable amount of annual rainfall to thrive. Plants are gathered each year for their rhizomes, some for propagation in the following season and some for consumption.
Turmeric is an important commercial crop, of which bulbs are used not only in cooking in nearly every kitchen, but also as a medical herb. Turmeric has digestive, carminative and anti-rheumatic properties. It is used in Ayurveda formulation since ancient times for curing muscular pain, giddiness, lungs, heating intestinal ulcer, etc. Turmeric is consumed as green as well as dried in the spice form and as ingredient to flavor the various vegetarian, non-vegetarian dishes and pickles.

Good tasty pickles, chutneys, curry powders are prepared from Turmeric cloves. Turmeric is also used to disguise the smell and flavor of salted meat and fish. The major occupation of the Indian rural people is agriculture and both men and women are equally involved in the process. Agriculture has been the backbone of the Indian economy and it will continue to remain so for a long time. It has to support almost 17% of world population from 2.3% of world geographical area and 4.2% of world's water resources. The present cropping intensity of 137% has registered an increase of only 26% since 1950-51.

Turmeric as an aromatic medicinal plant known to Indians since ancient times. Many scientists and historians argue that the South Asia is the original home of Turmeric; from there it might have spread to countries in the South East Asia and pacific islands where Turmeric is cultivated. There are Sanskrit texts belong to 5^{th} and 6^{th} centuries A.D describe the usages of turmeric. Turmeric is widely cultivated mainly in India, China, Taiwan, Indonesia, Sri Lanka, Java, Brazil, Peru, many parts of Africa and Australia. (Anonymous 2018)

Turmeric is an herbaceous perennial plant that grows up to 1 m tall with many branches with yellow to orange, cylindrical, aromatic rhizomes. The rhizomes are the most widely used part of the plant as cooking ingredient, medicine and color dye though the leaves and the stems are used for many purposes mainly cooking.

Turmeric has nearly 40 different genres and 400 species. The most common varieties of Turmeric are Curcumin longa, Curcuma aromatica, curcuma Amada, curcuma ablutophilia, curcuma zoaria.

India produces nearly 94 percent of the total turmeric production in the world and it consumes nearly 50 percent of the global market. Turmeric has been cultivated over an area of 1, 93,395 ha in India with a production of 10,51160 tons during 2016-17. India is the leading producer and supplier of turmeric in the world. However, export earnings have increased from Rs. 11558 Lakhs in 2000-01 to Rs.16480 Lakhs in 2006-07. The UAE, Bangladesh, Sri Lanka, USA and Japan are the major markets for Indian turmeric. India enjoys a monopoly position with a share of 90 percent in the international trade for turmeric. (Sakamma 2009).

Volume of turmeric produced across India in financial year 2018, by Telangana 294.56, Maharashtra 190.09, Tamil Nadu 116, Gujarat 78.91 (in 1,000 metric tons), (APEDA, 2018).

Turmeric is being propagated by rhizomes may be mother or fingers. The rhizomes should be treated with the 0.3 per cent Agallol or Dithane M-45 solution for 30 minutes and then dried in the shade before planting. Turmeric rhizomes are planted in the furrows by dibbling at a spacing of 30 x 30cm, and 15 x 15 cm. After dibbling the rhizomes are covered with the loose soil from the ridge.

Importance and need of the study

The production and productivity of turmeric in India are very low compared to many other countries. Ignorance of farmers about improved varieties, climate, soil and agro-techniques, diseases and pest damaging the crops and their control measures as well as post-harvest management are though main reasons, inadequate market support is also responsible for limiting the production and productivity indirectly.

Sowing techniques and type of seeding machines play an important role in seed placement and rhizome's emergence which ultimately affect crop growth and grain yield. The selection of suitable planting methods is dependent upon the time of planting, irrigation methods, amount of residue in the field and type of planting machines. Crop establishment using bed planting system is a new technique in the farming system turmeric cultivation.

Different bed planting configurations are used throughout the world depending on soil type, available machinery, farmer's preference and expertise. In general, increasing the width of the bed reduces total water used and increases land use efficiency and yield by reducing the uncropped furrow area.

At present there is a great demand for this crop in both local and international markets. Production and total planting areas have been maintained constantly while the export value has been increasing every year. The increasing demand both of home uses and industries has resulted in step rise in Turmeric prizes.

Manual planting of turmeric is both labors intensive and costly, resulting in various problems for farmers. The capacity of man is very low about 0.05 ha./man/day and payment for planting is 11.9 per cent of total cost of production (Jarudchai, 2002). Because of the high costs of the traditional methods of turmeric planting, cultivation and harvesting which is very time consuming and labor intensive, its large scale production is not economical and is therefore very limited.

Manual planting is labor intensive. There is acute shortage of manpower availability in the farmer's field during season. These factors have imposed a limitation on the size of farms which subsequently curtails the possible production output. Furthermore, farmers have a limited time frame in which to prepare the soil so that it has sufficient moisture for planting. This activity requires substantial manpower for planting the turmeric fingers before the soil dries up.

Due to the lack of appropriate planting, it is still grown in relatively small fields using traditional methods. But now because of its nutritional and pharmaceutical values, it has received economic interest worldwide. In recent years, many farmers have shown great interest in turmeric plantations. Successful turmeric crop with increased yield and better quality can be taken up by using drip irrigation by planting on raised beds, where harvesting require is easier reduced pest attack.

This research, therefore, concerns the need to improve the precision of the turmeric planter, which directly affects the yield, and the farmer's acceptance. The specific objectives of this research is to develop and standardize metering mechanism for automatic turmeric planter, which is, capable of singulating turmeric fingers and planting at predetermined depth, and plant spacing on raised bed.

Review of Literature

Physical properties of turmeric

Balasubramanian (2012) studied properties of turmeric rhizome (variety. IISR Alleppey Supreme). Sample was divided into three grades (I: 25-35 mm, II: 35-45 mm, III: 45-55 mm) according to its major dimension to study its physical properties. The average values of geometric property *viz*., length (30.38-50.60 mm), breadth (9.77-10.64 mm), thickness (5.18-6.44 mm), arithmetic mean diameter (15.82-21.91 mm), geometric mean diameter (12.77-13.76 mm), square mean diameter (24.24-28.58 mm), equivalent diameter (17.61-21.41 mm), sphericity (0.27-0.42), aspect ratio (0.20-0.35), unit volume (1641-2901 mm3), surface area (771-1265 mm2) and shape factor (1.63-1.77) for grades I, II & III are reported.

The gravimetric property *viz*., bulk density (260-348 kg/m3), true density (1341-1354 kg/m3) and porosity (74.53-80.93 percent) and frictional property *viz*., angle of repose (37.57-38.90°) and coefficient of friction with respect to different surface *viz*., aluminum sheet, mild steel sheet and plywood sheet for grades I, II and III were found to range between of 0.69-0.81, 0.84-0.94, 0.80-0.86, respectively.

Subhasini S (2015) Turmeric is the dried rhizome of *Curcuma longa* L., an herbaceous plant native to tropical south East Asia. It is mainly cultivated in India, Jamaica, Pakistan, China, Peru, Bangladesh, Taiwan, Sri Lanka, Indonesia and Myanmar. India is the largest producer, exporter and consumer of turmeric in the world. Within the plethora of spices, turmeric known as “Indian Saffron” plays an important role in Indian cuisine and it also has several medicinal properties. The physical properties of turmeric rhizomes were determined at different moisture contents such as 8, 12 and 16 percent *viz*., size, bulk density, true density, and porosity, by using standard procedures. It will found that the physical dimensions of turmeric rhizome were increased with increasing the moisture content. The bulk density and true density of turmeric rhizome at 12 per cent moisture content were 647.5 kg/m^3 and 1303.3 kg/m^3 respectively. The porosity of turmeric rhizomes will found to be 67.3 percent.

Preetham *et al*. (2018) A field experiment will conducted at Horticultural Research Station, Adilabad (Northern Telangana Zone) of Telangana state for two consecutive years 2016 and 2017 to find out the performance of Salem variety of turmeric with two planting materials (Split and full rhizome) and three population levels (1,48,148, 74,074 and 98,765 plants ha^{-1}) on raised beds. The two years study revealed that full rhizomes used as planting material showed significantly higher mean plant height of 34.20, 58.47, 80.61 and 82.68 cm at 60, 90, 120 and 150 DAP respectively. Full rhizome treatment showed significantly higher number of mother rhizomes (3.86), primary fingers (12.54), secondary fingers plant-^{1} (15.98), clump weight plant-^{1} (1035 g), girth of mother rhizome (19.13 cm), weight of mother rhizome (86.18 g) and fresh rhizome yield (21.58 t ha^{-1}) over split rhizome treatment. Plant population densities did not differ significantly for plant height and number of leaves plant-1 during all growth stages during both the years of study. Maximum number of mother rhizomes (3.97), primary fingers (13.05), secondary fingers (16.94), clump weight plant^{-1} (1140 g), girth of mother rhizome (21.60 cm) and weight of mother rhizome (87.65g) were recorded in 74,074 plant population treatment. Maximum fresh rhizome yield (20.14 t ha-1) will recorded with plant population stand of 1,48,148 plants ha^{-1} which will on par with plant population stand of 98,765 and 74,074 plants ha^{-1}.

Cultivation Methods of Turmeric

Islam *et al.* (2002) [23] conducted experiments to find out the optimum plant spacing for maximizing the yield of turmeric. The highest average yield of 17.87 tha^{-1}will obtained from 45 cm x 10 cm plant spacing which will closely followed average yield of 16.77 t ha^{-1} by 45 cm x 20 cm plant spacing. The lowest average yield of 13.42 t ha^{-1}will recorded from 60 cm x 30 cm. They concluded that planting geometry of 45 cm x 10 cm is suitable agronomically, but also a spacing geometry of 45 cm x20 cm is economically viable for turmeric production.

Amzad (2005) [5] stated that the required weight of seed rhizome is about 50 g of mother rhizome which must include secondary and tertiary rhizomes that develop, to mature plants to give comparable yield. Other than weight, size of seed rhizome is an important factor for the selection of good rhizome seeds of turmeric. Finally the turmeric seed rhizome should be the part of mother or primary rhizome with large diameter. It should have weight within 30 to 40 g. The secondary and tertiary daughter rhizomes should be removed from the seed rhizomes used for planting.

Kandiannan and Chandaragiri (2008) conducted experiments to study the effect of variety, planting time and spacing on turmeric yield. They concluded that the variety BSR-2 performed better than BSR-1 in terms of growth and yield. The plant geometry 30cm x 15cm recorded significantly higher growth, nutrient uptake and yield than 45cm x 15 cm and 60 cm x 15 cm spacing.

Frictional properties

The frictional properties such as coefficient of friction and angle of repose are important in the design of hoppers, conveying system, threshers etc. (Sahay and Singh, 1994). Frictional properties help to understand the behavior of the given material motion on different surfaces.

Angle of repose

The angle of repose is the angle between the base and the slope of the conformed on a free vertical fall of granular materials over a horizontal plane. The size, shape, moisture content and orientation of the grains affect the angle of repose (Sahay and Singh, 1994).

Mishra and Kulkarni (2009) identified the angle of repose of fresh turmeric rhizome, by using a bottomless cylinder placed on a flat surface and filled it with turmeric rhizomes. The cylinder will rise slowly allowing the rhizomes to flow and assume a natural slope in the form of cone. The diameter and height of cone will measured and angle of repose calculated. The angle of repose for fresh turmeric rhizome will 33°.

Ajav and Ogunlade (2014) [2] reported that the angle of repose of fresh ginger rhizomes measured by using a specially constructed topless and bottomless box made of plywood, with are movable front panel will 48°.

Coefficient of friction

The coefficient of friction between granular material is equal to the tangent of the angle of internal friction for the material. The frictional coefficient depends on grain shape, surface characteristics and moisture content.

Athmaselvi and Varadharaju (2002) [8] studied the static coefficient of friction of turmeric rhizomes of BSR-1, BSR-2 and Erode varieties with respect to moisture content on four metallic surfaces *viz.*, aluminum, mild steel, galvanized iron and stainless steel. The static coefficient of friction increased with increase in moisture content of rhizomes in all metal surfaces.

Jayashree (2009) reported the coefficient of friction of ginger rhizomes. The coefficient of friction of fresh ginger rhizomes at a moisture content of 81.70 percent (wb) against plywood, stainless steel, aluminum, galvanized iron and mild steel surfaces will 0.53, 0.57, 0.68, 0.72 and 0.74, respectively.

Mishra and Kulkarni (2009) found out the co-efficient of friction of turmeric rhizomes (variety-Sangli). The static coefficient of friction on four metal surfaces namely, mild steel (0.51 to 0.66), galvanized iron (0.47 to 0.64), aluminum

(0.40 to 0.56) and stainless steel (0.37 to 0.54) with increase in moisture range from 12.40 to 21.85 percent (db).
Ajav and Ogunlade (2014) [2] reported the coefficient of friction of ginger rhizomes. The coefficient of friction will obtained on three different structural materials the values obtained are 0.40 on glass, 0.49 on stainless steel and 0.55 on wood.

Development of Various Planters

Sadhu (1982) designed and developed a tractor operated two row onion set planter. The metering mechanism used will horizontal plate type. The onion set hopper will a vertical, cylindrical shell mounted coaxially above the metering mechanism. The hopper consisted of an outer shell fitted around the outside at the bottom. This left an annular space between the two cylinders. The annular space will utilized as a passage to guide the onion-sets into the drop chute during operation. There were two guide plates in the annular space, fixed to the inner cylinder, adjacent to the outlet openings, so that the flow of onions will diverted into the drop chutes.

Odigdoh and Akubuo (1991) designed and tested a two-row automatic mini setm planter and it has a special two-row ridger which makes small, 50 cm ridges at 90 cm row spacing. The prototype can operate at upto 7 kmh^{-1} and makes ridges and automatically meters and plants the yam mini setts in the ridges at a spacing of about 24 cm within the row and at a planting depth of 4 cm.
Sahoo and Srivastava (2000) developed a three-row ridger planter for planting soaked okra seed on ridges. The seed metering mechanism in the planter is of inclined plate type. The power is transmitted from ground wheel to metering system through chain and sprockets. The machine has four ridger bottoms with runner type furrow opener for making ridges. The seed is placed in these ridges at desired depth. The ridge size and depth of placement of seed are adjustable. The implement is operated by a 35 hp tractor. The field capacity of the machine will 0.2 har^{-1} at an average operating speed of 2.27 kmh^{-1}. The field efficiency of the planter was 66.5 percent.

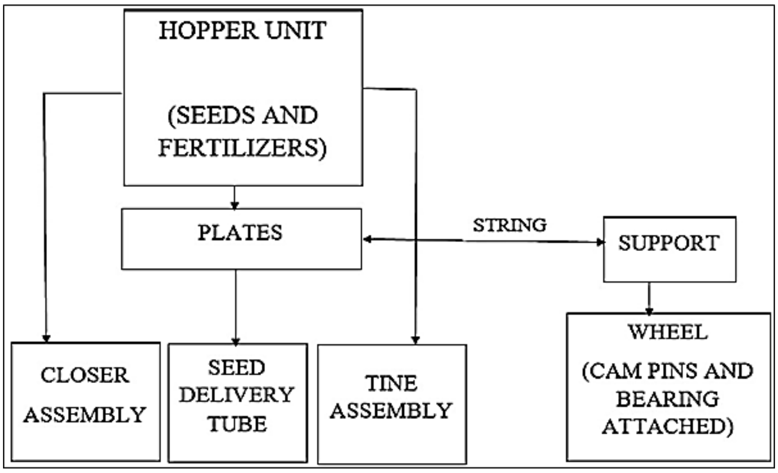
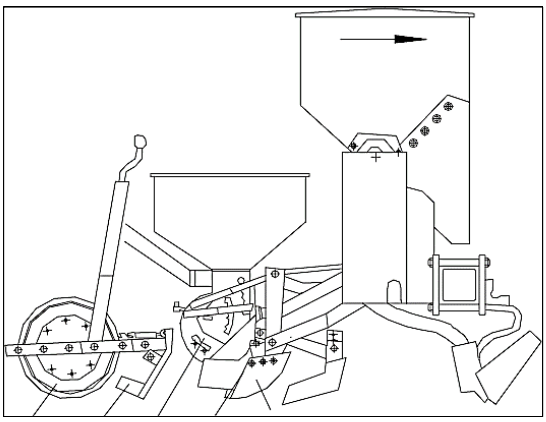


Fig 1: Block diagram of seed sowing machine

Singh (2004) stated that potato planting in large parts of eastern Uttar Pradesh is done manually and manual operation results in varying and non-uniform plant stand and requires large labour force in field preparation as well as planting operations. To overcome the shortage of labours, timeliness in operation and planting problems, a two-row tractor operated potato planter ridger will tested. Necessary modifications were made in the machine based on the test results and it will introduced to the farmers. The modified potato planter will widely accepted among the potato growers in eastern Uttar Pradesh.
Kazmeinkhah, *et al*., (2007) designed a semi-automatic Transplanter machine, in order to cultivate sugar beet seedling. This machine willable to cultivate seedling with the row distance of 65cm, seedling distance of 50.3 cm and13cm depth. Standard deviation in comparison to the desired position will 4.5 percent along the cultivation row line and 3.6 percent perpendicular to the cultivation row line.
Vasuki (2012) designed and developed a tractor operated turmeric planter and it consist of ridger bottom, rhizome hopper, cup feed rhizome metering mechanism, mainframe, shoe type furrow opener, ground wheel and chain sprocket power transmission drive. The turmeric rhizome planter will evaluated in the laboratory for its performance. The performance indices *viz*., singles, doubles, triples and missing index of turmeric planter were 67.9, 12.55, 3.52 and 15.95 percent respectively. The mean and standard deviation of rhizome spacing in the laboratory tests were 28.95 cm and 9.73 cm, respectively. The tractor operated turmeric planter will tested in the field for performance at an optimized speed of 1.5 km h^{-1}.The average plant to plant spacing will 22.68 cm after 30 DAP. The field capacity of the turmeric planter was 0.27 ha h^{-1}. The total time required for the planting operation will 5.78 hr ha^{-1} with a field efficiency of 64.28 percent. The seed rate will reduced to 1027 $kgha^{-1}$bythe developed planter.



Planter Design Factors

Seed Metering Mechanisms for Planters

The metering mechanisms must work effectively in order to continuously meter seeds at a uniform rate and spacing with respect to the ground surface at travelling speed. Besides, the metering mechanism should meter the seeds with minimum damage. However, the metering mechanism parameters that affect the performance are discussed in the subsequent sections.

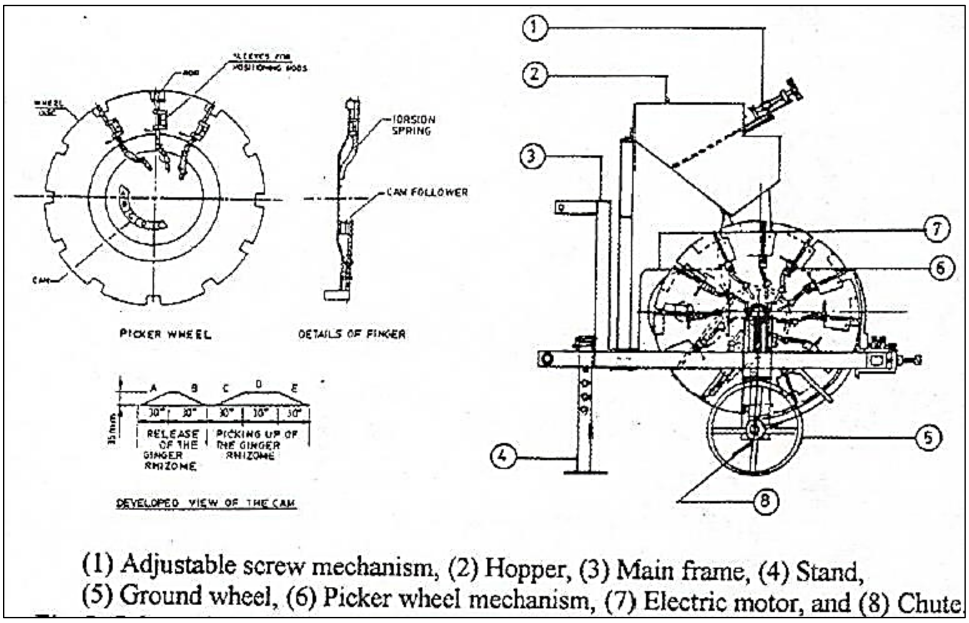


Fig 2: Schematics of picker wheel type metering mechanism mounted in test setup

Richy *et al*. (1961) described the inclined plate type metering device. It will a variation of a cup feed. An inclined seed plate with indented cells in the edge dipped in a wall of seed fed under a baffle plate from the hopper, lifted the seeds and dropped them into a delivery tube. This type of feed, like a cup feed, required no cut off which sometimes might cause seed injury but it might be affected by hopper tilt and rough ground. This type of metering mechanism will used in some vegetable planters. Speed of rotation will required to be slow to avoid centrifugal force, which would throw the seeds from the cells prematurely. Some planters used two plates dropping alternately into one seed tube for more capacity.

Roharbach *et al*. (1969) developed a stochastic model for system designed to produce uniform spacing of planted seed as a consequence to statistically characterize the plant spacing produced by these system using horizontal plate seed metering mechanism. Number of seed that occupied a seed cell at the time of discharge, the drop error and the survival factor were also studied.

Ryu and Kim (1998) designed roller type metering device for precision planting. The design parameters affecting the uniformity of seed placements were investigated from the geometry of roller and brush and the roller will designed accordingly. Experimental results showed that the designed metering roller made a better performance of seed placement than that made by the previous one. The method could also be applied to the design of metering devices for precision hill dropping of other crops.

Wanjura and Hudspeth (1969) recommended that the metering device on a seeder should be located as low as possible so that seed should fall freely to the bottom of soil trench.

Kepner *et al.* (1987) reported that metering of tuber and seed flow has two aspects. The first is the metering rate, which refers to the number of seeds that are released from the hopper per unit time. Metering rate is an important parameter for any planter to achieve desired plant population. The second is that, seeds must be dropped through the seed tubes to achieve a uniform spacing of seed placement in each row.

Kepner *et al.* (1987) reported automatic potato planter have vertigo, rotating picker wheels with devices to either pierce or grip individual seed pieces and then drop them into the furrow. The picker pin type is the most common type of mechanism. Each arm or head of the picker wheel had two sharp picking pins that pierce a seed piece in the picking chamber carry it over to the front, and then release it above the furrow. The position of the picker pins on each head is adjustable to accommodate various sizes of seed pieces. The spacing of seed pieces in the row is controlled by the speed ratio between the ground wheels and the picker wheels.

Kachman and Smith (1995) reported that the spacing of the seeds are affected where the mechanism fails to select or drop a seed resulting in large spacing between seeds; or because the mechanism selects and drops multiple seeds causing small spacing between seeds. To achieve accurate seed spacing, different parameters that affect the placement need to be optimized for a specific size of seed *viz.*, shape of the seed hole on the disc for simulation of seed, speed of the disc to regulate seed spacing and vacuum pressure required to hold, transport and drop the seed.

Mathanker and Mathew (2002) stated that picker wheel type and horizontal disk cell type metering mechanisms perform well under suitable working conditions. The planting mechanisms were tested at various linear (peripheral) speeds. The percentage of cell filled varies from 128 to 143 per cent, physical damage from 6.5 to 16 per cent and missing cells percentage from 12 to 14.2 percent as the linear speed varied from 5.5 to 18.1 m min^{-1} respectively for the picker wheel type metering mechanism. For the horizontal disc cell type metering mechanism percent cell filled varies from 80 to 99 per cent and percentage of physical damage from 1to3 per cent as the linear speed varied from 5.1to21.7 mm in^{-1}respectively. Hence, picking wheel mechanism will found suitable for automatic ginger planters with optimum linear speed in the range of 10 to 12 m min^{-1} and horizontal disc cell mechanism will found suitable for semi- automatic ginger planters with optimum linear speed range of 5 to 8 m min^{-1}.

Jayanand Kumar (2004) investigated the design of planter in relation to the physical properties of seeds. They reported that in the absence of devices for the positive removal of seeds from the cells of the plate, seeds drop by gravity and as the peanut seeds are non-spherical, they move slowly leading to the variation in seed spacing. In order to achieve the uniformity in seed spacing and accuracy in seed rate, it is essential to use the metering plate with size of cells matching the size of seeds.

Sahoo and Srivastava (2008) investigated the seed pattern characteristics of soaked okra seed with different metering systems *viz.*, vertical roller, horizontal plate, horizontal plate (edge drop), inclined plate, cell size *viz.*, maximum seed dimension, 10 per cent more than maximum seed dimension, 25 per cent more than maximum seed dimension and cell speed *viz.*, 10, 14, 18, 24 rpm. They concluded that the average spacing will close to theoretical spacing for vertical roller, horizontal plate, horizontal plate (edge drop) with cell size 10 per cent more than the maximum seed dimensions. But incase of inclined plate the average spacing will close to theoretical spacing with the cell size equal to maximum seed dimensions. The quality of feed index will influenced highly by the metering systems, cell size and cell speed. The quality of feed index decreased with increase in speed. However, with increase in cell speed to 14 rpm only 5 percent decrease of quality of feed index will observed. The cell speed mostly influenced the multiple index, miss index and degree of variation. The metering system influenced the seed damage the most followed by cell speed. Incline plate metering system will found the best for planting soaked okra seed.

Srivastava (2008) evaluated four different types of metering systems on the basis of their performance parameters i.e. average spacing, quality of feed index, multiple index, miss index, degree of variation and seed damage for metering soaked okra seed at three levels of cell size and four levels of cell speed. The average spacing observed will close to the theoretical spacing for cell size equal to maximum seed dimension. The quality of feed index will influenced highly by metering systems, cell size and cell speed. The metering systems influenced the seed damage the most followed by cell size. It will concluded that inclined plate metering system will best suited for metering soaked okra seed.

Gbabo (2020) Planting of turmeric has been a challenge to the farmers in Nigeria due to the absence of planting machine. The performance tests of the fabricated machine were carried out using three levels of turmeric rhizome lengths (30 mm, 45 mm and 60 mm) at three levels of operational speeds (8km/h 10km/h and 12km/h). The results revealed that there will no steady pattern in the increase or decrease of miss index with increase in turmeric rhizome length and machine operational speed. The highest percentage turmeric rhizome miss index of 35 per cent will recorded for turmeric rhizome length of 30cm at machine operational speed of 10km/h whereas the lowest percentage turmeric rhizome miss index of 15 per cent will obtained for turmeric rhizome length of 60cm at the machine operational speed of 12km/h. The machine operational speed and size of the turmeric rhizomes affect the field capacity of the machine. The highest capacity of 0.96ha/h will recorded at the highest operational speed of 12km/h. The lowest field capacity of 0.63ha/h will recorded at the lowest machine speed of 8km/h. The developed machine could reduce drudgery involved in manual turmeric planting and save about substantial amount of labour and operating time.

Furrow openers for planters

Dransfield *et al.* (1964) [19] reported that rake angle of a furrow opener will proportional to the force on it. They reported that both the horizontal and vertical forces are increased with increase in rake angles.

Shaaf *et al.* (1981) evaluated different types of opener *viz.*, shoe type, hoe type and disc type. They concluded that the hoe opener tends to penetrate more easily than the disc opener for loamy soil.

Marakoglu and Carman (2009) conducted study on effects of parameters of a cultivator share on draft force and soil loosening in a soil bin. The test tool variables included rake angle to the horizontal of 12.5^{o}, 17.5^{o} and 22.50^{o} working depths of 70, 110 and 150 mm and forward speed of 1.08, 1.55 and 2.08 ms^{-1}. The results indicated that the draft force will increased from 420 to 2025N. The greatest distributed area occurred at rake angle of 22.5^{o}, forward speed of 2.08 m s^{-1} and depth of 150 mm.

Jiraporn *et al.* (2010) conducted experiments to study the performance of three types of furrow openers *viz.*, shoe, shovel and hoe for a tractor operated 10 row garlic planter in terms of depth of the clove placement, clove space disturbance, draft requirements and extension of soil disturbance occurring during their operation. As the depth of operation increased, soil disturbance and back flow increased. The shovel type opener showed the maximum germination percentage of 83.3 per cent with a draft force of 1.067 kgf per opener, which will 27 per cent higher than the hoe type opener.

Chaudhuri (2011) evaluated the performance evaluation of various types of furrow openers for seed drill. The results stated that increase in rake angle increased the draught and vertical force acting on the furrow opener. The values of the rake angle for the lowest draught are usually around 25^{o} to 30^{o}. Increase in the width of furrow opener increases draught and reduces the amount of soil covering the seed in the furrow. Disc type furrow openers are generally satisfactory for conventional tillage due to lower draught, less soil disturbance and less variation in depth. Hoe-type furrow openers place seed close to the furrow bottom and create more soil disturbance which increase the soil moisture loss from the furrow. The best performance under zero tillage condition will given by the chisel, winged chisel, inverted-T and winged type furrow openers. Runner type furrow openers are suitable for sowing under conventional tillage system only for shallow sowing under irrigated conditions. Winged, inverted-T and hoe-type furrow openers are suitable for seed cum fertilizer drills.

Ridger type furrow openers

The ridge planting is a practice that eliminates conventional seed bed preparation or which combines with planting operation (Raghavendra *et al*., 2013). The ridges and furrows can be simultaneously formed by using tractor drawn semi-automatic rhizome planter. The ridges were formed by the wings of the ridger and the seeds were placed while the formation of ridges. The main function of ridge forming is to ensure weed control, infiltration and storage of runoff water in order to conserve moisture.

Mathur and Pandey (1992) reported that the minimum specific draft for lateritics and clay loam soil will recorded at a rake angle 28° of the furrow opener.

Zhang and Araya (2001) reported that the draft force of a mould board plough had increased steeply when rake angle will more than 30°.

Abd El-Tawwab *et al*. (2007) [1] reported that the design parameters of the furrow openers has the share rake angle and wing shape and angle strongly affect the shape of the ridge profile. In addition, one of the most important parameters strongly affect the required draft force is the share rake angle. For better penetration of soil, the rake angle of the share should be ≥25° to the ground.

Design factors affecting the planter performance

Buitenwerf *et al.* (2006) [13] reported that the accuracy of planting (distance in the seeding furrow) is influenced for a large part by the cup-belt unit of the potato planter. A more regular shape (lower shape factor) does not automatically result in a higher accuracy. A sphere (golf ball) in most cases will deposited with a lower accuracy than a potato. This will caused by the shapes of the guiding duct and cups.

Jiraporn *et al.* (2010) conducted experiments to optimize the height of seed delivery tube above ground level for 10 row tractor operated garlic planter. They observed that the height of the seed delivery tube at 30 cm above ground level provides the lowest variation of 25mm, from the line of motion at a forward speed 1.67 km h^{-1}.

Kocher *et al.* (2011) studied the variation in corn seed spacing from a John Deere Max Emerge and meter planter will evaluated in a laboratory setting for two seed tube conditions (new or worn) with two examples of corn seed shape (round or flat). They had measured the seed spacing uniformity by using three seed spacing uniformity parameters:

i) Coefficient of Precision (CP).
ii) Multiples index.
iii) Miss index.

Differences were perceived in all three seed spacing uniformity parameters due to the seed tube condition. The new seed tubes had better seed spacing uniformity than the worn seed tubes, within each example of the seed shapes (round or flat). For the seed used in this experiment, is the round corn seed which had better seed spacing uniformity, for each of the seed tube conditions (new or worn).

Operational speed parameters

Bjerkan (1947) [11] reported that slippage on ground wheels, too high planting speeds and non-uniform seed size were the causes of irregular planting. An average slippage value of 5 percent for rubber tyres and 15 percent for steel wheels will suggested.

Chhinnan *et al.* (1975) [16] show the effect of planting speed on metering and seed accuracy. Then they reported that higher planting speeds resulted in more skips, higher seed placement error and higher average spacing.

Hamad and Banna (1980) [22] and Amin (1983) showed that the length of feeding-wheel mechanism speed and transmission rotor has positive effect on the amount of sowing rate. There is also a good deal of variation between different machines in the accuracy of spacing, depending on whether there is appreciable wheel slip and on whether the potatoes are allowed to role in the furrow bottom. Generally, the forward speed of this type of machinery is not over 3.2 kmh^{-1}.

Ismail (1989) stated that the operational speed of manual filling of buckets of metering mechanism in planting machine at is very low and in the range from 1.5 to1.6 kmh^{-1} (0.4 to 0.44 $msec^{-1}$). He stated that the time span necessary for the operation of taking out potato seed from the box and placing it into the bucket amounts to approximately 0.75 seconds.

Seed box parameters

Kualand Egbo (1985) said that the seed box or hopper in planters should be trapezoidal, rectangular or oval in shape. The capacity of the box also varies depending on the size of machines. Trapezoidal shape of seed box helps to ensure a free flow of seed.

Awady and El-Said (1985) [9] developed a simple planter whose hopper is built from iron sheeting with 45° slopping bottom.

Bosai *et al.* (1987) [12] reported that the hopper must have an optimum capacity which ensures the uniformity of feed seeds and continuous motion to the seeds metering mechanism, independent of the direction of motion of the swing unit.

Performance evaluation of planters

Anonymous (1986) the Ludhiana Research Center developed a tractor operated ridger planter with an inclined plate metering mechanism, ground wheel and provision for shifting the position of the furrow opener. Its field capacity will 0.2 to 0.33 ha/hr at forward speed of 2 to 2.5 km/hr Kachman and Smith (1995) evaluated a planter using a single seed metering mechanism, the ability to place seeds at a given distance apart in a row will an important factor in evaluating a planter's performance. The distance between plants within a row is influenced by a number of factors including multiple seeds dropped at the same time, failure of a seed to be dropped, failure of a seed to emerge and variability around the drop point. The measures compared will the mean, standard deviation, quality of feed index, multiples index, miss index, and precision. The results show that planter operated at 3.2 km/h, the multiple index will 2.23 per cent, miss index 34.7 per cent, quality of feed index 63 per cent and precision 13.4 per cent of the theoretical spacing.

Griepentrog (1998) [21] states that quality of horizontal and vertical distribution of seeds is influenced by row spacing, sowing depth, soil conditions, seeder design, seed density and operator skill. The mean spacing (X), the standard deviation of the spacing between plants (SD) and the coefficient of variation (CV) are commonly used for describing seed spacing uniformity. The mean spacing is influenced by seed or plant density and longitudinal distribution. For common grain drills, a CV of 20 per cent is an acceptable accuracy achieved by mechanical and pneumatic machines when they are performing well.

Misener (1979) evaluated the cup and pick type potato planters. Co-efficient of variation in spacing, number of seeds fill and number of seed piece skips were determined for each planter. In general, the pick type planter will slightly more effective than the cup type planter. The co-efficient of variation of spacing for the cup and pick type planters ranged from 59.2 to 87.1 and from 55.3 to 68.7, respectively. The average number of doubles per 30.5 m of row length ranged from 5 (6.2 percent of seed pieces) to 65 (33.6 percent) for the cup type and from 5 (6.8 percent) to 52 (29.0 per cent) for the pick type planter over various forward speeds and nominal spacing's. The range of skips for the cup planter will 3 (3.2 percent) to 22 (14.7 percent) and for the pick type planter, varied from 3 (3.0 percent) to19 (12.1 percent) per 30.5 m of row length.

Griepentrog (1998) [21] reported mean spacing (X), standard deviation of the spacing between plants (SD) and coefficient of variation (CV) for describing seed spacing uniformity. The mean spacing will influenced by seed or plant density and longitudinal distribution. For common grain drills, a CV of 20 percent will an acceptable accuracy achieved by mechanical and pneumatic machines when they were performing well.

Panning *et al.* (2000) evaluated sugar beet planting performance for a precision planter designed for shallow planting of small seeds, a general purpose planter designed for row crops, and a vacuum metering general purpose planter designed furrow crops that will equipped with three seed tube designs. In their field study, the most uniform seed spacing for each planter configuration occurred at the lowest speed of 3.2 kmh^{-1}. For all planter configurations, the seed spacing uniformity decreased as the forward speed increased from 3.2 to 8.0 km h^{-1}. Seed spacing uniformity determined in laboratory tests will greater than, or equal to, seed spacing uniformity determined in field test.

Mari *et al.* (2002) carried out an experiment to evaluate the performance of potato planter. The planter will powered by Fiat-480 diesel tractor at low 3rd gear speed. The performance of tractor planter determined were moisture content of 15.73 percent, fuel consumption will 24.04 *l* h^{-1}, the travel reduction will 5.04 per cent, field efficiency will 67.47 percent, field capacity will 0.80 hah^{-1}.

Singh and Gulati (2003) designed and developed manually drawn two-row cup type potato planter for planting and spacing of potato tubes at uniform row to row and seed to seed distance. The machine consists of 2 number of 4 ply rating and 100 mm wide rubberized belts with 16 numbers of 45 mm diameter mild steel sheet cups riveted on each belt. Power to both metering mechanism and eccentric plate has been given from the ground wheel through an arrangement of chains and sprockets. The effective field capacity of the planter is 0.5 ha/day with 0.5 per cent missing.

Celik *et al*. (2007) [14] evaluated four different type seeders for seed spacing, depth uniformity, and plant emergence at three forward speeds (3.6, 5.4 and 7.2 kmh^{-1}). The planter types were: no-till planter, precision vacuum planter, universal planter, and semi-automatic potato planter. The sowing uniformity of the horizontal distribution of seeds will described by using the multiple index, the miss index, the quality of feed index, and the precision in addition to the means and standard deviations of the sample methods.

Satpathy and Garg (2008) conducted studies on a two row semi-automatic vegetable Transplanter to assess its performance at different speeds, soil moistures and seedlings ages with respect to plants missing, planting angle and planting depth for two vegetable crops *viz.*, tomato and chilli. They reported that best results were obtained at 10 percent soil moisture content with 5-week seedlings in tomato and 17 to 19 weeks seedlings in chilli crop. The average field capacity of the machine will 0.09 $hah^{-1}$and 0.12 $ha^{-1}$with corresponding field efficiencies of 71.5 percent and 67.2 percent at an operating speed of 1.0 km h^{-1} and 1.2 km h^{-1} respectively. The missing will 3 to 4 percent and the average depth of planting varied from 2.33 to5.32 cm in tomato crop and 2.31 to 5.16 cm in chilli crop. The labor and time saving were 70 to 75 percent and 75 to 78 percent will obtain with the machine over manual transplanting.

Al-Gaadi and Marey (2011) [4] evaluated the effect of forward speed and tuber characteristics on tuber spacing for a cup belt potato planter. They had selected the three level of forward speeds (1.8, 2.25 and 3 km h^{-1}) and three tuber sizes (35 to 45, 45 to 55 and 55 to 65 mm) the performance of the planter will evaluated in terms of mean tuber spacing (M), the coefficient of variation (CV), the multiple index (MULTI), the miss index (MISI). Tuber sizes of 35 to 45 mm resulted better tuber spacing uniformity than other tested tuber sizes. Forward speed of 2.25 km h^{-1} had maximum efficiency and does not affect the seed tuber uniformity.

Al-Gaadi (2011) [3] investigated the performance of an auto feed cup-belt potato planter under different operating conditions with different tuber shapes for whole and cut tubers. He concluded that the coefficient of variation and missing index were proportional to the forward speed and inversely proportional to the gate height and speed ratio. The highest CV (coefficient of variation) and MISI (missing index) values were 68.4 percent and 16.42 percent respectively for cut tubers at 3 km h^{-1} travel speed at a speed ratio of 1.22 and 80 mm gate height. The lower multi index values were observed in the cut tubers and the maximum multi value of 7.76 percent will observed in the whole tubers.

Dixit *et al.* (2015) [18] conducted the performance evaluation of tractor mounted vertical belt type paired row potato planter for planting potato variety Kufri Jyoti on beds in controlled traffic. The field capacity of the paired row planter wills 0.24 ha h^{-1} at an average forward speed of 2.5 km h^{-1}. Missing, multiples and seed damage for paired row planter will 3.3, 1.5 and 1.5 percent, respectively, whereas in case of automatic planter, it will 5.0, 1.8 and 10.0 percent, respectively. Performance evaluation of vertical belt of paired row potato planter will also conducted at farmer's field covering approximately 117 ha. The results obtained were of similar pattern. Overall planting performance of the machine and potato crop stand will found to be satisfactory for the belt type paired row planter.

Chukwudi Muogbo (2019) the experiment will randomized in a factorial design of three planter levels of rhizome lengths (30, 45 and 60 mm) and operational speeds of 8, 10, and 12 kmh-1. An average mass of 3 kg of wholesome turmeric rhizomes were introduced into the hopper of the planter and planted in 90 m2 of experimental plot. During field evaluation of the machine, the effective field capacity, field efficiency, missing index, multiple index and planting depth were considered; whereas laboratory tests were conducted to evaluate the planter's seed rate, percentage rhizome bruise wheel slippage and fuel consumption. Results obtained show that the maximum seed rate was 0.283 th-1. The maximum percent bruised turmeric rhizome will found to be 30.08 percent. The mean effective field capacity varied between 0.63-0.96 hah-1, at operational speeds of 8 and 12 kmh-1, respectively and 45 mm rhizome length. The mean field efficiency will obtained to be 65.8 percent. The maximum wheel slippage of 4.37 percent and fuel consumption of 3.8 lha-1 were obtained at the machine speeds of 8 kmh-1 and 12 kmh-1, respectively; whereas the minimum wheel slippage of

3.14 percent and fuel consumption of 2.2 lha-1 were obtained at the machine speeds of 12 kmh-1 and 8 kmh-1, respectively for the range of the studied turmeric rhizome length. The highest and lowest percentage turmeric rhizome miss index of 35 percent were recorded for turmeric rhizome length of 30 mm at a speed of 10 kmh-1 and 8 kmh-1, respectively. An average planting depth of 68 mm will obtained. The numerical optimization approach will adopted to obtain an optimal operational parameters of 12 kmh-1 speed and 45 mm turmeric rhizome grading size with an overall desirability index of 0.73. An economic evaluation will calculated using the principle of payback period which will obtained to be very small (1.64 years) compared to the life of the planter of 17 years. Prospects for future works were suggested.

References

1. Abd El-Tawwab IM, Badaway ME, El-Khawaga S. Developing and performance evaluation of a locally fabricated sugar beet planter. Misr J Ag. Eng. 2007;24(4):648-665.
2. Ajav EA, Ogunlade CA. Physical properties of ginger (Zingiber of ficinale). Glob. J Sci. Frontier Res. 2014;14(8):23-29.
3. Al-Gaadi KA. Performance evaluation of cup-belt potato planter at different operation conditions and tuber shapes. American-Eurasian. J Agric. Environ. Sci. 2011;10(5):821-828.
4. Al-Gaadi KA, Marey. Effect of forward speed and tuber characteristics on tuber spacing uniformity for a cup belt potato planter. Middle E. J Sci. Res. 2011;8(4):753-758.
5. Amzad HM, Ishimine Y, Akamine H, Motomura K. Effects of seed rhizome size on grow than yield of turmeric. Plantprod. Sci. 2005;8(1):86-94.
6. Anonymous. Report of MPUAT, Udaipur; c2010.
7. ASAE [American Society of Agricultural Engineers]. Moisture measurement-forages. St. Joseph, Mich. 1993;S358:2.
8. Athmaselvi KA, Varadharaju N. Physical and thermal properties of turmeric rhizomes. Madras Agric. J. 2002;89(10-12):666-671.
9. Awady MN, El-Said SA. Design factors for simple grain drill feeding mechanism. Misr. J Ageic. Eng. 1985;2(2):33-49.
10. Bakhtiari MR, Loghavi M. Development and evaluation of innovative garlic clove precision planter. J Agric. Sci. Technol. 2009;11:125-136.
11. Bjerkan JA. The precision planting equipments. J Agric. Eng. 1947;28(4):54-57.
12. Bosai ES, Verniaev OV, Smirnov II, Sultanshakh EG. Agricultural machines theory, construction and calculations. Oxionian press Pvt. Ltd., New Delhi. 1987;1:237-275.
13. Buitenwerf H, Hoogmoed WB, Lerink P, Muller J. Assessment of the behavior of potatoes in cup-belt planter. Biosys. Eng. 2006;95(1):35-41.
14. Celik A, Ozturk I, Way TR. Effects of various planters on emergence and seed distribution uniformity of sunflower. Appl. Eng. Agric. 2007;23(1):57-61.
15. Chaudhuri D. Performance evaluation of various types of furrow openers on seed drills-are view. J Agric. Eng. Res. 2001;79:125-137.
16. Chhinnan MS, Young JH, Rohrbach RP. Accuracy of seed spacing in peanut planting. Trans of the ASAE. 1975;18(1):828-831.
17. Collins BA, Fowler DB. Effects of soil characteristics depth, operating speed and opener design on draft force during direct seeding. Soil and Tillage Res. 1996;39:199-211.
18. Dixit A, Verma A, Singh A, Manes GS. Performance of tractor mounted vertical belt paired row potato planter. Agric. Res. J. 2015;52(1):59-61.
19. Dransfield P, Willatt ST, Willis AH. Soil to implement reaction experienced with simple tines at various angles of attack. J Agric. Eng. Res. 1964;9:220-224.
20. Dubey AK, Srivastava NSL. Development of furrow openers for animal drawn seed-cum-fertilizer drill for black soils. Procedings of the ISAESJC. 1985;1:39-43.
21. Griepentrog HW. Seed distribution over the area. Eur. Agric. Eng., 1998, 98-A-059.
22. Hamad SA, Banna AB. The grain drill Cz 3.6 and its viability for sowing different size seeds. J Agric. Sci. Mansoura Univ. 1980;5:76-85. India stat. 2013. www.indiastat.com.
23. Islam F, Karim MR, Shahjahan M, Hoque MO, Alam MR, Hossain MA. Study on the effect of plant spacing on the production of turmeric at farmer's field. J Plant Sci. 2002;6:616-617.