Herbal hydration-dehydration treatments for improving vigor, viability and productivity in tomato (*Lycopersicon esculentum*.Mill) cv. PKM 1

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DEPARTMENT OF PLANT BREEDING AND GENETICS
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
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(A. SRI PUNITHA)

ABSTRACT

Herbal hydration-dehydration treatments for improving vigor, viability and productivity in tomato (*Lycopersicon esculentum*.Mill) cv. PKM 1

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Experiments were carried out to identify the herbal extracts for improving vigor, viability and productivity in tomato cv. PKM 1. Three herbals namely *Calotropis gigantia, Morinda tinctorius, Ocimum basilicum* each at 15% and 20% concentration and soaking durations of 1.50h and 2h were used for seed treatment and foliar spray (20%) at vegetative, flowering and both the stages combined.

Laboratory studies revealed that seed soaking using *Morinda tinctorius* at 20% concentration for 2h was very effective for the maintenance of vigor and viability parameters. The next best treatment was *calotropis* extract. The advantageous effect was obvious through seed quality parameters viz., speed of germination, germination percentage, seedling length and dry matter production.

In field trials, seed treatment with leaf extract of *Calotropis gigantia* at 20% for 2 h in combination with foliar spray at 20%, during vegetative and flowering stages was effective. The physiological and yield parameters viz., LAI, CGR, RGR, NAR, plant height, number of leaves, number of branches and biomass production, fruit yield and seed yield were higher in this treatment. The other herbs *viz*., *Morinda tinctorius*

and *Ocimum basilicum* were less effective, but the effect was better than water soaking and control.

The vigor and viability was assessed under artificial ageing conditions for six days and also after three months of storage at ambient conditions. The beneficial effect of herbal treatment was evident only on vigor parameters *viz*., speed of germination, shoot length, root length, dry matter production, electrical conductivity and lipid peroxidation. The effect could not be observed on percentage germination. The advantageous effect could be attributed to repair of membranes and counteraction of lipid peroxidation.

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF ANNEXURES

CHAPTER -I

INTRODUCTION

Vegetables are considered as essential building blocks of any diet. They are good sources of vitamins and minerals, low in fat and high in dietary fiber and complex of carbohydrates. Among the vegetable crops, tomato occupies a prime position all over the world for its fleshy fruits.

Globally China ranks first with an area of 14.5 lakhs ha and a production of 31 million tons per annum. Next to China, India occupies the major cultivated area of 5.4 lakhs ha with a production of 7.1 million tons, ranking 5^{th} in position. Tamil Nadu occupies seventh position among the states with a cultivated area of 0.25 lakh ha and annual production of 3 lakh tons with productivity of 12,500 kg per ha.

In any production programme, seeds play a vital role. Quality inputs in the absence of quality seeds will not improve production. Maintenance of vigor and viability during storage is utmost important. Ageing or seed deterioration is a major problem in vegetable seeds. The relative humidity and temperature prevailing during storage largely influence the rate of deterioration of seeds.

Several attempts have been made to slow down the rate of deterioration in storage with pre-storage treatment to maintain the vigor of seeds. Hydration-dehydration method, a relatively low cost technology has been successfully employed for preservation of seeds (Basu, 1976; Dharmalingam, 1982; Pan and Basu, 1985), seedling performance and increased yield in a number of vegetable crops (Basu and Dhar, 1979; Kundu and Basu, 1981).

Current agricultural practices necessitate an increase on the usages of inorganic fertilizers for higher yield. The adverse effect of synthetic inputs on soil as well as foliar application, in field crops warrants attention (Metting *et al.,* 1991).

Medicinal plants are nature's wonderful gift and used widely in traditional systems like Ayurveda, Siddha, and Unani. Nearly 9800 species have been identified as effective in alleviating the diseases in various systems. While the usages of medicinal herbs have been fully exploited for human and animal health care, no attempt has been made for utilization in agriculture, particularly for seed treatment to maintain vigor and viability.

Plants are the potential source of natural antioxidants. The phytochemicals are the secondary metabolites of plants (Walton *et al.,* 1999). Carotinoids, flavonoids, cinnamic acids, benzoic acids, ascorbic acid, tocophenols, etc are some of the antioxidants produced by the plant or their substances, which can attempted for enhancing agricultural productivity. Herbal hydration-dehydration was effective in improving storability and productivity in a number of crops (Vanitha, 2005; Sujatha, 2006). Identification of organic sources for seed and foliar treatment for yield improvement will be advantageous and in the present agricultural scenario herbals are major candidates for research.

Against this back drop, studies were initiated to elicit information on the following aspects.

To identify the effect of medicinal herb extract for,

i. Pre-storage treatments to maintain seed vigor and viability.

ii. Enhancing productivity through seed and foliar treatment.

CHAPTER - II

REVIEW OF LITERATURE

Success of every seed programme lies on the maintenance of vigour and viability of seeds up to next sowing season. In India, seeds have to be stored invariably under hot and humid climate that ultimately has a bearing on emergence and productivity. The poor performance of seed may generally be due to several factors, of which, physiological quality of seed after storage is of immense importance. Ageing is a natural irreversible phenomenon resulting in seed deterioration, which leads to loss of vigour and viability. The variables that affect viability, the changes associated with storage and the mechanism relating to vigour and viability maintenance using organic/ inorganic resources, like medicinal herbs have been discussed here under.

2.1. Factors responsible for storage life of seeds

Seeds during storage undergo deterioration at various levels resulting in loss of vigour and viability. The longevity of seeds in storage is influenced by five major factors *viz*, (i) Genetic (ii) Initial quality of the seed at the time of storage (iii) Moisture content (iv) Ambient relative humidity and (v) Temperature of storage environment. Among several factors that affect storage life, seed moisture content (Reusche, 1987 in peanut; Ellis *et al.,* 1992; Zhang *et al.,* 1993 in barley and rice; Rajasekaran, 2001 in niger; Anuja and Aneja, 2004 in soybean; Shantha Nagarajan *et al.,* 2004 and Padma and Reddy, 2004 in bhendi) play the major role.

Decrease in vigour and viability during storage is rapid in most of the vegetable seeds, largely due to prevailing high temperature and relative humidity (Bhatia *et al.*, 2002 and *Bellard et al.,* 2006 in bittergourd) in the storage environment.

Relative humidity has a greater influence on longevity of seed because seed moisture content is directly associated with the relative humidity of the atmosphere (Harrington, 1972 in lettuce; Agarwal, 1993; Dey and Mukerjee, 1984 in soybean; Palanisamy, 1987 in bhendi; Khattra *et al.*, 1988 in pigeon pea; Balamurugan *et al.* 2003 in sunflower and Pallavi *et al*., 2003 in sunflower; Vanniarajan *et al.*, 2004 in black gram). The other factors like oxygen pressure (Roberts and Abdalla, 1968), microflora (Bhatia *et al.,* 2002) and insects (Lande *et al.,* 1986 in peanut; Patil *et al.,* 2006 in chickpea) also affect the quality of seeds to a greater extent.

2.2 Physiological and biochemical changes associated with seed deterioration

2.2.1. Physiological changes

The rate of seed deterioration has a major impact on the physiological potential of the seeds (Desai, 1976). It is manifested as changes in colour, delayed germination, reduced tolerance to adverse storage and germination conditions and (Shanmugavel *et al.,* 1995), reduction in seedling growth (Anderson, 1970 in barley; Shanmugavel *et al.,* 1995 in soybean and Ram and Wiesner, 1998; Kharab and Dahiya, 2000 in pigean pea).

2.2.2. Biochemical changes

a) Loss of enzyme activity

Many scientists have attempted to correlate enzyme activity with loss of seed viability in different crops. A high correlation between respiratory level of seeds and seedling growth have been reported (Molina *et al.,* 1995 in maize) and deteriorated seeds showed high respiratory quotient values (Woodstock and Grabe, 1967 in maize). The loss of vigour might be the outcome of reduction in the synthesis of

enzymes, nucleic acid and amino acid (Saxena and Maheswari, 1980 in soybean; Sabir-Ahamed, 1989 in soybean; Sheperd *et al.*, 1995 in rice; Jegathambal, 1996 in sorghum; Punithavathi, 1997 in ragi and Kavitha, 2002 in blackgram). Changes in the levels of dehydrogenase, catalase, peroxidase, amylase, phosphatase and glutamic acid decarboxylase have been found to be associated with seed viability during storage (Chabra, 1984 in mungbean; Dal, 1984 in pigeonpea; Maheswari, 1987 in soybean; Kalpana *et al.*, 1994 in pigeonpea; Anuja *et al.*, 2004 in soybean and Vanitha, 2005 in sunflower, blackgram and maize).

c) Loss of membrane integrity

Seed deterioration alters the differential permeability properties of the membranes. As a consequence, vigour can be measured by membrane integrity (Koostra and Harrington, 1969 in cucumber; Berjak and Villiers, 1972 in lettuce). The electrical conductivity is a good indicator of loss of membrane integrity (Matthews and Bradnock, 1968 in peas and french bean; Mullet and Wilkinson, 1979 in pea). Increase in conductivity might be due to increase in permeability of membrane and leaching of the electrolytes such as sugars, amino acids and organic acids (Takayanagi and Murakami, 1969 in rape seed; Ramamoorthy and Karivaradharaju, 1989 in tomato; Anuja *et al.*, 2004 in soybean; Vanniarajan *et al.*, 2004 in black gram; Sujatha *et al.*, 2006 in blackgram).

d) Denaturation of lipoprotein membrane

The degradation of lipoprotein cell membranes by free-radical induced lipid peroxidation reactions are the basic reasons of senescence and ageing. Harrington (1972) reported that oxidation of membrane as a major mechanism of seed deterioration. In stored seeds, degenerative changes in cell membrane lead to damage of phospholipids causing an increase in lipid peroxidation (Villiers, 1972 in carrot and

okra; Powell and Matthews, 1979 and 1981 in pea; Dadlani and Agarwal, 1983 in soybean; Ramamoorthy and Basu, 1984 in peanut; Kathiravan *et al.,* 2008 in jatropa). Several workers reported the relationship between lipid peroxidation and seed deterioration under different conditions (Powell and Harman, 1986 and Powell and Matthews, 1981 in pea;, Buchvarov and Gantcheff, 1984; Wilson *et al.*, 1986 in soybean; Kalpana *et al.,* 1994 in pigeonpea; Jeng *et al.,* 1994 in soybean; Selvaraj *et al.,* 2004 in rice; Sujatha *et al.*, 2005 in blackgram).

e) Free radical in seed deterioration

Free radicals are the important products during oxidative damage of polyunsaturated lipids in cell and cellular components in the biological system (Tappel, 1973 in soybean). Basu *et al.,* 1985, found that the physio-chemical treatment slowed down the mustard seed deterioration by reducing lipid peroxidation and free radical reactions.

Various forms of free radicals have been observed in living tissue, each with a differing capability for cell damage (Grille and Joenje, 1991; Larson, 1997). Khan *et al*. (1997) studied the role of oxidative damage in seed ageing and reported that lipid peroxidation and free radical accumulation were significantly correlated with the decline in germinablity in rapidly aged soybean seeds. Induction of specific isoforms of free radicals and peroxides scavenging enzymes in different tissues has been reported in several species subjected to oxidative stress (Anderson *et al.,* 1995; Bagnoli *et al.,* 1998).

2.3. Effect of containers on viability maintenance

The deterioration of physiological quality of seeds during storage could be attributed to containers (Kumar and Singh, 1984; Rajasekaran *et al.,* 2005) and seed

treatment (Basu and Rudrapal, 1980). Several workers suggested that the moisture content of the stored seeds was maintained in polyethylene bag compared to cloth bag due to the prevention of moisture entry into the container (Sku and Tarar, 1991 in sunflower; Tomer *et al.,* 1993 in lentil; Padma and Muralimohan Reddy, 2004 in okra) and the deterioration was less in seeds stored in polythene bag (Kathiravan *et al.*, 2008 in lab lab).

2.4. Hydration-dehydration treatment

Hydration followed by drying of seed is one of the novel method that results in modifying physiological and biochemical properties of seed. (Henckel, 1964; Basu and Dasgupta, 1974; Basu, 1976 in wheat). Wetting-drying seed treatment given to number of crops significantly reduced the deterioration of seeds during storage and also improved the crop productivity (Mitra and Basu, 1979 in tomato). Beneficial effect of soaking and drying treatment are probably due to enhanced metabolic functions and activation of repair mechanism at cellular level (Joseph and Noir, 1989).

The efficacy of hydration-dehydration treatments on the maintenance of vigour and viability of seeds has been demonstrated by several workers in radish (Rudrapal and Nakamura, 1988), peanut (Basu, 1990), soybean (Jeng and Sung, 1994 and Mandal *et al.*, 2000) and okra (Kapri *et al.,* 2003). This method differs from the conventional pre-sowing treatment in that, short duration soaking - drying treatments are given to stored seeds with a sufficient time gap between treatment and sowing. The effect is spectacular and highly reproducible not only in maintaining vigour and viability but also in maximizing productivity (Mitra and Basu, 1979 in tomato; Saha *et al.,* 1990 in soybean; Palanisamy and Punithavathi, 1998 in ragi).

Andrea *et al.*, (1993) reported that hydration- dehydration is a viable alternative to improve the performance in medium physiological quality seeds but not in high

vigour seeds of tomato. Gu *et al.,* (1993) was of the opinion that hydration – dehydration treatments increased the activity of superoxide dismutase, catalase and peroxidase in germinating seeds of tomato and reduced melondialdehyde content, with a reduction in membrane damage and efficient mitochondrial functions. The beneficial effects of physico-chemical seed treatment have been interpreted on the basis of control of free-radical pathology.

Hydration-dehydration treatments with chemicals also showed a significant increase in germination, seedling vigour, dehydrogense enzyme activity and yield attributes (Pallavi *et al.,* (2003) in sunflower, Girase *et al.,* (2007) in sorghum; Dhedhi *et al.,* (2007) in groundnut).

Mukhopadhyay, *et al*. (1997) recommended the use of potassium phosphate in hydration-dehydration treatment for the improvement of immediate and post storage seed germinability and established the relationship between germination improvement and the reduction of volatile aldehyde production in french bean and soya bean. Mehra *et al.,* (2003) reported that aerated hydration treatment improved the rate of germination in mustard seeds under stress condition.

2.5. Pre-sowing seed management

Henckel (1964) identified hardening or imbibition and drying of seeds as one of the pre-sowing seed management techniques that modifies physiological and biochemical nature of the seed to induce drought resistance. Pre-sowing hydration-dehydration seed treatments gave better seedling establishment and increased yield in several crops *viz*., sugar beet (Basu and Dhar, 1979), wheat and mustard (Rudrapal and Basu, 1979), tomato (Mitra and Basu, 1979), carrot (Kundu and Basu, 1981), wheat (Mandal and Basu, 1983), soybean (Saha *et al.,* 1990) , sunflower (Khan *et al.,* 2003), mustard (Mondal *et al.,* 2004), pulses (Vanitha, 2005; Sujatha, 2006).

Pre-sowing seed vigour enhancement treatments have been very effective to achieve rapid and uniform seed germination of several vegetable species Taylor *et al.,* (1998). Priming of seeds using polyethylene glycol (PEG) is known to improve the rate and uniformity of seed germination (Smith and Cobb, 1991) but lack practically utility. Several studies have related this concept to enhanced germinability and attributed to the repair of membranes and subsequent buildup of germination metabolites (Fu *et al.,* 1988 in groundnut; Bailly *et al.,* 2000 in sunflower and Pandita *et al.,* 2001 in papaya, Hsu *et al.,* 2003 in bittergourd; Srimathi *et al.,* 2006 in blackgram).

2.6. Accelerated Ageing

The accelerated aged seeds generally show a marked depression in their ability to germinate (McDonald, 1999), which is also associated with increased leaching of organic and inorganic constituents (Aswathaiah *et al.,* 1987). Artificial aging reduced the rate of radical extension (Abdalla and Roberts, 1969 in peas and bean; Argerich and Bradford, 1989 in tomato) and shoot growth (Chauhan *et al.*,1984 in barley; Vanitha, 2005 in maize, blackgram and sunflower; Sujatha, 2006 in pulses) due to non availability of food reserves. The activity of enzymes like acid phosphatase, phosphomonoesterase, dehydrogenase, amylase, catalase, peroxidase were also decreased during accelerated ageing (Basavarajapppa *et al.* 1991,).

The deleterious effects of accelerated ageing on the germination process were associated with the damage occurring at the membrane, nucleic acid and protein levels (Fujikura and Karssen, 1995).

2.7. Antioxidants

Antioxidants are the substances when present in low concentration effectively protects the cell membrane against the oxidative damage induced by oxidants (Rajagopal, 2001). The secondary metabolites of plants are the potential source of natural antioxidants (Walton and Brown (1999).

In dry seeds, lipid soluble non-enzymic antioxidants (such as α tocopherol) act as potential mechanism of defence when enzyme systems are impaired at low seed water contents and in aged seeds decrease in the activity of lipid soluble antioxidants (Senaratna *et al*., 1988; Pukacka, 1988) have been observed. Both the enzymatic and non-enzymatic antioxidant compounds present in seeds prevents the oxidative damage by scavenging free radicals formed in the membranes or other seed components. Enzymic antioxidants (super oxide dimutase, catalase, glutathione peroxidase and other peroxidases) detoxifies hydrogen peroxide and dimutates O_2 to H_2O_2 (Oliver *et al*., 1990 in maize; Smok *et al*., 1993 in sunflower; Van pijlen *et al*., 1995 in tomato; Sung, 1996 in soybean; Bailly *et al*., 1998 and 2000 in sunflower and Posmyk *et al*., 2001 in soybean). The non-enzymic antioxidants like ascorbic acid (directly scavenges H_2O_2, OH^- and O_2^-) α tocoperol, glutathione (scavgenges H_2O, OH^-), β careotene (scavenges OH^-, O_2^-) and proxy radicals are also effective in controlling free radical formation (Woodstock *et al*., 1983 in onion, McKersie and Stinson, 1985 in soybean; Pallanka and Smirnoff, 1999 in pea; De Gara *et al*., 2000 in maize).

Hence when seeds are given with priming treatments they stimulate the activities of enzymes, *viz,* amylase, dehydrogenase, glucose 6-phosphate ehydrogenase and peroxidase (soybean (Saha *et al.*, 1990); sweet corn (Smith and Cobb, 1991);

tomato (Parera and Cantliffe, 1994); carrot (Shantha Nagarajan *et al*., 2004); blackgram (Vanitha, 2005; Sujatha, 2006).

2.7.1. Sources of antioxidants

In the wake of identifying antioxidants rich natural sources, many medicinal plants have become major candidates for research, though seeds treated with inorganic sources of antioxidants *viz*., benzoic acid, sodium hydrogen phosphate, α-tocopherol and ascorbic acid have been effective in prolonging the shelf life of the seeds (Mandal and Basu, 1983, Bhattacharjee and Gupta, 1985). The enzymic antioxidants *viz*., catalase, peroxidase and superoxide dismutase and non-enzymic antioxidants *viz*., vitamin C, α-tocopherol and glutathione have been identified in pepper species (Karthikeyan and Rani, 2003), Phyllanthus (Raphael *et al.*, 2000), Indian squill (Tripathi *et al.,* 2001), cowhage (Tripathi and Upadhyay, 2001), chicory (Saroja *et al.,* 2000 and Kameshwari, 2002), Caesalpinia (Padma *et al.,* 2000), sweet basil (Gangrade *et al.*, 2001) and aswagandha (Jain and Jain, 2001). They have not been attempted for seed treatment.

2.8. Importance and scope of medicinal plants

The medicinal plants play an important role in Indian systems of medicine *viz*., Ayurveda, Sidda and Unani. The use of phytomedicines as a remedy for various human ailments is well established. Many medicinal plants have been found to possess principle compounds for treating diseases and serve as a source of raw materials for the manufacture of semi synthetic and synthetic products (Akerela, 1993). Plant extracts and their isolated constituents have always been an important part of various therapeutic systems (Sastry, 2000).

It is estimated that out of 15000 plant species available in the country (Pushpangandan, 1995), about 9800 plant species are being used for medicinal purposes (Singh, 2000). Awareness of the medicinal plants and their usage has increased tremendously in the recent times (Ved *et al.,* 2000) in health care.

2.9. Chemical composition of medicinal herbs

a) Calotropis

Calotropis latex showed analgesic activity against acetic acid induced writhing. It produced marginal analgesic effect, which was comparable to aspirin. It contains calotroin D1 and D II, two proteinase containing carbohydrates (Abraham *et al.*, 1979; Sengupta *et al.*, 1984; Dewan *et al.*, 2000) that can be exploited for seed treatment.

b) Ocimum

Ocimum is considered as a holy plant and has diverse uses in the indigenous systems of medicine. The ocimum leaves have antibacterial, antifungal and insecticidal properties (Bhattacharya *et al.,* 1996). It is an important source for eugenol, thymol and methyl cinnamate used in perfumery (Sanda *et al.,* 1998). The other constituents of ocimum are methylisoeugenol and sesquiterpenes *viz*. δ-cadinene, β-caryophyllene, monoterpenes *viz*. β-ocimene and phenylpropanoid elemicine (Ariaya and Jens, 2003), commonly utilized in pharmaceutical industries. The antioxidant activity of *Ocimum basilicum* may be due to the presence of natural flavonoids like rutin and isoquercitin (Skaltsa and Philiaos 1986), and terpenoids (Muralidharan and Dhananjayan, (2005) which offers scope for vigour and viability maintenance.

C) Morinda

M. citrifolia fruit contains relatively larger quantity of non-polar antioxidant compounds. It was also found that the drying methods had significant impact on the antioxidant activity, total phenolic and flavonoid content of the extracts. Research has revealed the potential of *Morinda citrifolia* L. as source of various antioxidants in roots, fruits and leaves (Mohd Zin, *et al.,* 2002) and has not been used for seed treatment and foliar spray so far.

2.9.1. Seed priming with leaf extract

Use of leaf extract for improvement of seed quality and yield has been reported in a number of crops (Jegathambal, 1996 in sorgum; Rathinavel and Dharmalingam, 1999 in cotton). The advantageous effect of botanicals *viz.* pungam and prosopis leaf extract for seed hardening over inorganics ($ZnSO_4$) was reported by Renugadevi *et al.,* 2001 in blackgram. In the same crop, Kavitha *et al.,* 2003, demonstrated that a combination of pungam leaf extract with DAP, $ZnSO_4$ and $FeSO_4$ was effective in enhancing vigour and viability parameters. In blackgram, aged seeds hardened with pungam leaf extract recorded higher germination and seedling vigour (Begam and Krishnasamy, 2003).

Krishnasamy (2004) reported that seed hardening with leaf extract of *Bougainvilla* and *Vitax* recorded maximum germination. Selvakumari *et al.,* (2007), revealed that seed fortification with leaf extract of hibiscus exhibited maximum germination percentage and vigour characters. Vanitha *et al*., 2008, reported that herbal hydration-dehydration treatment with chicory leaf extract exhibited higher activity of dehydrogenase and peroxidase and lower amount of leachate sugars and electrical conductivity in maize.

CHAPTER - III

MATERIALS AND METHODS

The lab experiment was carried out during 2008 – 2009 with the aim of evaluating the efficacy of three herbals extracts *viz*., *Calotropis gigantia, Morinda tinctorius, Ocimum basilicum* on tomato cv. PKM 1. The seeds were procured from Department of Horticulture, Agriculture College and Research Institute, Madurai.

Field experiments were conducted at Agricultural College and Research Institute, Madurai, situated in the Southern region of Tamil Nadu at 9^0 5' North and 70^0 5' East and at an altitude of 147 m above MSL having the soil properties of sandy clay loam (Annexure 1) with a pH of 7.9. The following experiments were conducted to standardize the effect of eco-friendly seed treatments using herbal extracts for maintenance of seed vigour, viability, productivity and storage potential.

3.1. Standardization of duration of accelerated ageing.

3.2. Evaluation of herbal extracts *viz*., *Calotropis gigantia, Morinda tinctorius, Ocimum basilicum* to control seed deterioration during ageing

3.3. Efficacy of herbal extracts as seed treatment and foliar spray on field performance

3.1. Standardization of duration of accelerated ageing

Fresh seeds of tomato cv. PKM 1, graded using 6/64" round perforated metal sieve, were packed in perforated butter paper cover and subjected to accelerated ageing in an ageing chamber maintained at 95±2% relative humidity and a constant temperature of 40 ± 1^0C (Delouche and Baskin, 1973) for a period of 10 days. The seeds were shuffled daily, sampled and allowed for moisture stabilization in a desiccator containing fused calcium chloride and evaluated for the following seed quality parameters along with control.

1. Germination

Germination test in quadruplicate using 100 seeds each with 4 sub replicates of 25 seeds, was carried out in paper medium (ISTA, 1999) following inclined plate method (Punjabi and Basu, 1982) in a germination room maintained at a temperature of 25 ± 1^0C and RH 96±2% with diffuse light (approx. 10h) during the day. Final count on normal seedlings was recorded on 14^{th} day and percentage germination was computed.

The inclined plate method has the following advantages over the existing roll towel method.

- ✓ Greater uniformity of seedling growth.
- ✓ Supply of equal amount of moisture to all seeds.
- ✓ Obviation of water logging.
- ✓ Little entangling of roots as the root grew vertically down without coiling or curving.
- ✓ Less fungal contamination.

2. Speed of germination

During germination test period observations were made daily from 2^{nd} to 14^{th} day. The emergence of the seedlings with the cotyledons and plumule was taken as the criterion for germination.

From the mean per cent germination on each counting date, the rate of germination was calculated employing the formula suggested by Maguire (1962).

$$\text{Rate of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \ldots + \frac{X_n - (X_n - 1)}{Y_n}$$

Where,

Xn = Percentage of germination n^{th} count

Yn = Number of days from sowing to n^{th} count

3. Root length

Root length of ten normal seedlings from the germination test was measured from collar region to the root tip and the mean was expressed in cm.

4. Shoot length

Shoot length of ten normal seedlings from the germination test was measured from collar region to the shoot apex and the mean was expressed in cm.

5. Seedling drymatter production

Ten normal seedlings used for growth measurements were placed in a cover and dried under shade for 24 h and then in a hot air oven maintained at 80^0C for 16 h and the weight was recorded. The mean weight was expressed in g 10 seedlings^{-1}.

Based on the results and certification standard norms, the number of days for accelerated ageing was fixed for tomato as 6 days for further studies.

Crop	Accelerated Ageing (Days)	Germination (%)	Minimum Indian Certification Standard (%)
Tomato	6	68	70

3.2. Evaluation of herbal extracts *viz., Calotropis gigantia, Morinda tinctoria, Ocimum basilicum* to control seed deterioration during ageing

3.2.1. Identification of optimum concentration and durations of leaf extracts before ageing

Five hundred grams in each of fresh *Calotropis, Ocimum* and *Morinda* leaves collected from the medicinal garden at Agricultural College & Research Institute, Madurai were macerated in pestle and mortar using 250 ml of alcohol for 12 h and filtered. The residue was soaked in 250 ml of distilled water for 36 h and filtered. Alcohol and water soluble extract were mixed and the volume was made up to 500 ml to constitute 100 percent solution. Using this 10, 15 and 20 percent concentrations were prepared.

Graded seeds were soaked in herbal extracts at 10, 15 and 20% concentrations along with water as control for 1, 1.50 and 2 h (1:0.3(W/V) of herbal extract and seed) under aerated conditions at room temperature (26 ± 1^0C). The treated seeds were dried under shade and then in a drying chamber (30 ± 0.5^0C) for 4 days to reach original moisture content (10±0.5% on wet weight basis) and assessed for germination and seedling attributes.

Based on the results the concentration and efficacy of herbal extracts against vigour improvement were rated as follows:

	Herbal Extracts	**Concentrations**	**Durations (h)**	**Ranking/Rating**
1.	*Calotropis gigantia*	10%	1	Not Effective
			1.50	Not Effective
			2	Not Effective
		15%	1	Less Effective
			1.50	Effective
			2	Effective
		20%	1	Less Effective
			1.50	Effective
			2	Effective
2.	*Morinda tinctorius*	10%	1	Not Effective
			1.50	Not Effective
			2	Not Effective
		15%	1	Less Effective
			1.50	Effective
			2	Effective
		20%	1	Less Effective
			1.50	Effective
			2	Effective
3.	*Ocimum basilicum*	10%	1	Not Effective
			1.50	Not Effective
			2	Not Effective
		15%	1	Less Effective
			1.50	Effective
			2	Effective
		20%	1	Less Effective
			1.50	Effective
			2	Effective

Immediately after treatment and accelerated ageing for 6 days, observation on germination percentage, seedling length brought out the better performance of herbal

extracts at 15 and 20% with a soaking duration of 2 h. These combinations were forwarded to natural ageing (Plate 1).

3.2.2. Assessing the efficacy of herbal extracts through accelerated ageing studies

Towards realizing the optimum concentrations and durations, for the maintenance of viability and vigour, seeds treated with herbals at a concentration of 15% and 20% with the durations 1.50 and 2 h, were packed in perforated butter paper cover and subjected to accelerated ageing in an ageing chamber maintained at 95±2% relative humidity and a constant temperature of 40 ± 1^{0}C for a period of 6 days. The following quality parameters and biochemical properties were studied to assess the effect of herbal extracts.

a) Germination

Carried out as per the method described in 3.1.1

b) Seedling length measurements

Ten normal seedlings from each replication were used for growth measurements. The seedling length was measured from the shoot apex to the tip of the primary root. The mean length was expressed in cm.

c) Seedling drymatter production

Recorded as per the method described in 3.1.5.

d) Electrical conductivity (EC)

Fifty seeds were washed with deionised water and soaked in 50ml of deionised water for 6 h. The seed steep water was used for estimating electrical conductivity in duplicate Presley (1958) in a Elico conductivity meter and expressed in dSm^{-1}.

e) Dehydrogenase activity

The dehydrogenase activity of the seeds was estimated in duplicate following the method of Kittock and Law (1968) with minor modifications. Twenty five seeds from each treatment were soaked in water for 18 h. From this, 10 embryonic axes were

separated and incubated in darkness with 5ml of 0.2% tetrazolium chloride solution in glass vials for 4 h. After incubation, the tetrazolium chloride solution was decanted and the embryos were thoroughly washed with distilled water and surface dried with blotters. The formazan was eluted by soaking the stained embryos in 5ml methyl cellosolve (2 methoxy ethanol) for 1h and the absorbance was measured using Cary UV spectrophotometer at 470nm.

f) Lipid peroxidation

Lipid peroxide formation in tomato was studied by the thiobarbituric acid (TBA) colour reaction outlined by Bernheim *et al*., (1948) in duplicate with minor modifications. Seeds from each treatment were soaked in distilled water for 18 h. 5ml of 0.5% TBA solution, 2ml of 1N H_2SO_4 and 5ml of methyl cellosolve were added to 100 mg of sliced embryos in a hard glass tube with close fitting glass lid. The mixture was thoroughly shaken and placed in an oven at 100^0C for 1h. After cooling, it was centrifuged at 2500 rpm for 10 min. The absorbance of the clear supernatant was measured in Cary UV spectrophotometer at 520nm.

3.2.3. Evaluation of herbal extracts for vigour, viability and biochemical properties during natural ageing.

Graded seeds of tomato were soaked in each of herbal extracts at 15 and 20% concentrations for 2 h. of soaking duration in each concentration as described earlier. After treatment seeds were dried back to the original moisture content and stored in gada cloth bag, gunny bag and polyethylene bag along with control for three months (from Jan 09 – March 2009) under ambient conditions (mean temp. 27± 1^0C, RH 66±2%). The stored seeds were evaluated initially and at monthly intervals for germination, seedling length, dry matter production, electrical conductivity, dehydrogenase activity and lipid peroxidation as per the procedures outlined elsewhere.

3.3. Efficacy of herbal extracts as seed treatment and foliar spray on field performance

All the three herbal extracts proved better at the concentrations of 15 and 20% for the soaking duration of 1.50 and 2 h for viability and vigour maintenance under accelerated ageing conditions and hence forwarded to the field trials.

Herbal extracts of *Calotropis gigantia, Morinda tinctoria, Ocimum basilicum* at 15 and 20% for 1.30 and 2 h were used for seed treatment in tomato as described earlier. Being organic a concentration of 20% was attempted as foliar spray. Foliar spray was given at vegetative (30^{th}) and flowering (45^{th}) phases and combinations of these two stages.

The treatments were given as follows

Factor 1: Herbals	*Calotropis* *Morinda* *Ocimum*
Factor 2: Seed treatment Concentrations	15% 20%
Factor 3: Soaking Duration	1.50 hours 2 hours
Factor 4: Foliar Spray	Control At vegetative stage At flowering stage At vegetative & flowering stage

The plan and layout of the experiment is presented in Annexure II. The experiment was carried out during rabi, 2009 at mini orchard of Agricultural College and Research Institute, Madurai. The morphological characters of the tomato cv. PKM 1 is given in Annexure III. The Factorial Randomized Block Design was employed with two replications (Plate 3).

The crop was raised with a spacing of 60 x 45 cm in a plot size of 4x4 m^2 with a population of about 55 plants/plot. Other cultural practices were given as per the crop production guide recommendations.

Observations on the following characters were recorded replication wise on five random plants.

(i) Plant height (cm)

The height of the plant was measured from the ground level to the tip of the main stem at vegetative (45 DAT) and fruiting stage (90 DAT) and the mean expressed in cm.

(ii) Dry weight (g plant^{-1})

After recording the observation, the shoots were cut into pieces and shade dried for two days followed by drying in oven at 80^0C for 24 h and mean weight expressed as g plant^{-1}.

(iii) Days to 50% flowering

The number of days required for 50% flowering of plants in five rows from the date of sowing was recorded.

(iv) Leaf area and leaf area index

Leaf area per plant was worked out by the length and breadth measurement method. The observation was recorded at 45, 90Days after transplanting (William, 1946).

Leaf area = L x B x K x n

Where,

L = length of the leaf (cm)

B = maximum breadth of the leaf (cm)

K = 0.691

n = number of leaves

Based on the leaf area plant $^{-1}$ the LAI was calculated by using the formula.

$$LAI = \frac{\text{Leaf area per plant}}{\text{Ground area occupied}}$$

(v) Total chlorophyll content

Chlorophyll content was determined in duplicate following method of Arnon, (1949), 1g at 45 and 90 DAT of leaf sample was weighed and ground using pestle and mortar with 20ml of 80% acetone and the homogenate was centrifuged at 5000 rpm for 5 min. and transferred to a 100ml volumetric flask. The volume was made upto 100ml with 80% acetone. The absorbance was measured at 652 nm against the solvent (80% acetone) as blank. The chlorophyll content present in the leaf sample was calculated and expressed in mg/g tissue.

$$\text{Total chlorophyll content (mg/g)} = \frac{A_{652} \times 1000}{34.5} \times \frac{V}{1000 \times W}$$

Where,

OD=Optical density

V = Final volume of chlorophyll extract

W = Fresh weight of the tissue

(vi) Crop growth rate (CGR)

Crop growth rate was estimated after Watson, (1958) and expressed in g $m^{-2}d^{-1}$

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where,

W_1 : Whole plant dry weight at t1 stage (g)

W_2 : Whole plant dry weight at t2 stage (g)

$(t_2 - t_1)$: Time interval in days between stages (g)

P : Land occupied by the plant (m^{-2})

(vii) Relative growth rate (RGR)

The RGR was calculated using the formula suggested by Williams, (1946) and expressed in mg $g^{-1}d^{-1}$.

$$RGR = \frac{\text{Log e } W_2 - \text{Log e } W_1}{t_2 - t_1}$$

Where,

W1 = Whole plant dry weight at t_1 stage (g)

W2 = Whole plant dry weight at t_2 stage (g)

$(t_2 - t_1)$ = Time interval in days between stages

(viii) Net assimilation rate (NAR)

The method proposed by Gregory (1917) and modified by Williams (1946) was employed for calculating the NAR which was expressed in mg $cm^{-2}d^{-1}$.

$$NAR = \frac{W_2 - W_1}{(t_2 - t_1)} \times \frac{\text{Log e } W_2 - \text{Log e } W_1}{L_2 - L_1}$$

Where,

W_1 = Whole plant dry weight at t_1 stage (g)

W_2 = Whole plant dry weight at t_2 stage (g)

L_1 = Leaf area index at t_1 stage (cm^2)

L_2= leaf area index at t_2 stage (cm^2)

$(t_2 - t_1)$ = Time interval in days between stages

The observation for the calculation of CGR, RGR were taken at 45, 90 and 135 days with the time interval of 45 days.

(ix) Single fruits weight (g)

Five fruits were randomly collected from each plot and weighed individually. The mean was expressed in gram.

(x) Number of fruits plant $^{-1}$

Total number of fruits in each plant was counted at maturity and then mean was expressed.

(xi) Fruit yield plant^{-1} (g)

Fruits from single plants were harvested and weighed and expressed in gram.

(xii) Number of seeds of fruit

Total number of seeds in each fruits was counted at maturity and then mean was expressed.

(xiii) Seed yield plant $^{-1}$ (g)

Seed yield plant^{-1} was recorded after drying to 10±0.5% moisture content and expressed in gram.

(xiv) Seed recovery percentage (%)

Seed recovery percentage was computed from seeds using a sample of 100g fruits obtained from individual treatments.

$$\text{Seed recovery percentage} = \frac{\text{Weight of seed (g)}}{\text{Weight of fruit (g)}} \times 100$$

(xv) Fruit weight plot^{-1} (g)

Fruits from the plants in the plot area were harvested and weighed and expressed in gram.

(xvi) Seed yield plot^{-1} (g)

The seeds obtained from the plants were weighed after drying to 10±0.5% moisture content on wet basis and expressed in gram.

(xvii) Seed yield (kg ha^{-1})

The seed yield recorded in each plot was used for calculating yield in kg/ha.

3.5.1. Statistical analysis

The results of different experiments were subjected to an Analysis of Variance and treatment differences tested for significance (P=0.05) after Gomez and Gomez (1984).Wherever necessary the percentage values were transformed in to arcsine values.

CHAPTER-IV

EXPERIMENTAL RESULTS

4.1 Standardisation concentration and soaking duration of herbal extracts for seed treatment

a) Germination (%)

Among the herbs *calotropis and morinda* had similar effect (94%). A concentration of 20% was effective compared to 10 and 15%. Among the soaking durations, 2 h recorded the higher germination (92%) (Fig1).

b) Shoot length (cm)

Increase in shoot length was observed in seeds treated with *morinda* and *calotropis* leaf extracts (8.8 cm). Higher concentration was more effective. Soaking for of 2h enhanced shoot length (Fig 1).

c) Drymatter production (mg/ 10 seedlings)

Morinda leaf extract at 20 % concentration was more effective recording higher drymatter production. Soaking for 2h enhanced dry matter production (Fig 1).

4.2 Effect of herbal extract as pre storage treatment on the storability of seeds

4.2.1. Standardization of duration of accelerated ageing

The initial germination of tomato was 86% and a gradual reduction in all the seed quality parameters was observed with accelerated ageing for 10 days and the loss in germination was faster after six days. The germination percentage was 34 percent at the end of ageing period. For the same period of ageing, speed of germination was

lowered from 11.62 to 6.05, root length from 9.16 to 4.0 cm, shoot length from 7.6 to 2.6 cm and dry matter production from 26.0 to 9.8 mg (Table 1).

4.2.2 Evaluation of treated seeds with different herbs on the storability of seeds

Seeds were assessed for vigor and viability immediately after the treatment and again for its storability through artificial ageing for 6 days and natural ageing for a period of 3 months.

a. Germination (%)

There was a decline in germination after ageing. It was 90 % in fresh seeds, 80% in artificially aged seeds and 83% in naturally aged seeds. Among the herbals *morinda* and *calotropis* were effective both in fresh (93%) and naturally aged seeds (88%). There was no significant difference among the concentrations in fresh seeds (89 and 90%) and artificially aged (81%) and naturally aged seeds (83%) (Fig. 3). Seed treatment with water was better than control and all the herbal treatments were significantly effective than water soaking (Table 2).

Under natural ageing, highest germination percentage was observed for seeds stored in polythene bag. Performances of cloth and gunny bags were similar. Among the herbals *calotropis* and *morinda* behaved equally (88%) (Fig 2).

b. Shoot length (cm)

Maximum shoot length was observed in fresh seeds (7.8 cm) followed by naturally aged (6.9 cm) and artificially aged seeds (6.3 cm) irrespective of herbals and concentrations. Among the herbals both *calotropis* and *morinda* (8.7 cm) were effective in fresh seeds. The same trend was observed in artificially and naturally aged seeds also. A comparison of concentrations indicated the effectiveness of 20%, irrespective of

herbs (Fig. 3). Under natural ageing, seeds stored in polythene bags recorded higher shoot length. Among the extracts *calotropis* (8.3 cm) was effective (Fig 2.)

c. Root length (cm)

Gradual reduction in root length was noticed in aged seeds. Maximum root length was observed in fresh seeds (9.0cm). In fresh and naturally aged seeds performance of *morinda* was better than others (11.7 and 10.7 cm). In artificially aged seeds the effect of *calotropis* was better than others (8.2 cm). Between concentrations 20% was effective in fresh and aged seeds (8cm) (Table 2)

Among the herbals *morinda* (11.0 cm) was effective. Under natural ageing, the highest root length was observed with polythene bag. Between the concentrations, 20 % was effective. (Fig.2)

d. Dry matter (mg)

The dry weight was higher in fresh seeds (26.6 mg). Among the herbals, *morinda* (33.0 mg) was effective followed by *ocimum* (32.9 mg) both in fresh and aged seeds. In contrast, under natural ageing *ocimum*, was better (29.2mg) followed by *morinda* (29.1mg) (Table 3).

A comparison of concentrations revealed no variation in fresh seeds and aged seeds. In naturally aged seeds, 20 % concentration performed better (24.2mg). Under natural ageing, higher dry matter was observed in seeds stored in polythene bag. Among the herbals *morinda* (32.7 mg) was effective (Fig2).

e. Electrical Conductivity (d S m^{-1})

The membrane integrity in terms of EC in fresh seeds was lower (0.061) compared to aged seeds. All the herbals were effective than water and control. Among

the herbs, *morinda* showed significantly lower EC (0.043) followed by *calotropis* (0.050) and *ocimum* (0.056mg) in fresh seeds. The same trend but at a higher magnitude was evident in aged seeds too. Irrespective of herbals extracts, a concentration of 20% was effective in fresh and naturally aged seeds. (Table 3)

Under natural ageing, minimum electrical conductivity was recorded with seeds stored in polythene bag. Among the herbals *morinda* (0.051) has recorded minimum electrical conductivity (Fig 2).

f. Lipid Peroxidation

The lipid peroxidation was minimum in fresh seeds (0.171) compared to aged seeds (0.223 in accelerated and 0.182 naturally aged seeds). In fresh and naturally aged seeds *morinda* was effective (0.166 and 0.179 for fresh seeds) followed by *calotropis* (0.167 and 180). But in artificially aged seeds performance of *morinda* (0.197) alone was effective.

Between concentrations the difference was not significant both in fresh and naturally aged seeds. A concentration of 20% (0.182) was better in accelerated aged seeds. (Table 3)

Among the storage containers, seeds stored in polythene bag recorded minimum lipid peroxidation values (Fig 2).

4.3. Efficacy of herbal extracts as seed treatment and foliar spray on field performance

4.3.1. Plant height (cm)

The plant height was higher in treated plots compared to control, in both stages of growth viz., 45 and 90 days after transplanting. Calotropis extract (53.3 cm) had an

edge over other herbal extracts (morinda (48.3 cm), ocimum (47.0 cm)). Irrespective of herbal extracts, a concentration of 20 % was effective (47.4cm) and a soaking duration of 2 h was necessary to attain maximum benefit for this parameter (48.7 cm). A combination of seed treatment with spraying at vegetative and flowering produced maximum height in all the herbs (65.7, 54.7 and 54.9 cm for calotropis, morinda and ocimum) (Table 4). The same trend with minor variations, was evident after 90 DAT also, where calotropis at 20% concentration (67.1cm) and a soaking period of 2 hr recorded higher plant height (58.3cm) (Table 5).

4.3.2. Number of leaves per plant

In both stages of growth viz., 45 and 90 days after transplanting, maximum number of leaves was noticed in treated plots compared to control. *Calotropis* extract (29.0) had more no of leaves. Irrespective of herbal extracts, a concentration of 20 % was better (25.2) and soaking duration of 2 h (26.0) was effective. A combination of seed treatment with spraying at vegetative and flowering produced more leaves in all the herbs (42.6, 35.8 and 32.8) (Table 6). The same trend was observed after 90 DAT also (Table 7).

4.3.3. Number of branches

Plants raised from treated seeds enhanced the number of branches compared to control and water. Maximum values were observed in calotropis leaf extract (24.5), followed by ocimum (23.3) and morinda (22.7) after 90 DAT. Irrespective of herbal extracts, higher concentration produced more number of branches (23.1) and a soaking duration of 2h recorded higher value for this parameter (24.3). A combination of seed treatment with spraying at vegetative and flowering produced more branches in all the herbals at (28.9, 27.0 and 25.8 at 90 DAT for calotropis, ocimum and morinda). (Table 8).

4.3.4. Dry weight (g/plant)

After 45 DAT, *calotropis* leaf extract recorded maximum dry weight of 10.8g. This was closely followed by *morinda* (10.6g) and *ocimum* (10.2g). Seed treatment combined with foliar spraying at vegetative and flowering stage recorded higher dry weight (11.9 g for *calotropis*, 11.6 g for *morinda* and 10.3 g for *ocimum*). Among concentrations, 20 percent recorded higher dry weight (11.2 g for *calotropis*, 10.7 g for *morinda* and 10.3g for *ocimum*). Among the durations, soaking for 2h proved better for all the herbals (Table 9).

The same trend was observed after 90 DAT, wherein the *calotropis* leaf extract, given as seed treatment and foliar spray at vegetative and flowering stage recorded higher dry weight (34.1 g) followed by *morinda* (33.2g) and *ocimum* (32.7 g). All the herbal extracts were effective than water and control. Among the concentrations, 20 percent enhanced dry weight (31.2 g). Among durations, 2h soaking recorded higher values (31.91 g) (Table 10).

4.3.5. Total chlorophyll content (mg/g)

The chlorophyll content was higher in all the treatments compared to water and control. After 45 days of transplanting, a combination of seed treatment and foliar spray at vegetative and flowering recorded higher chlorophyll content in *morinda* (2.75 mg) followed by *calotropis* (2.63 mg). In general, *morinda* leaf extract increased the total chlorophyll content (2.51 mg) compared to control (2.13 mg). *Morinda* at 20 percent concentration (2.54 mg) and 2 h of soaking duration (2.61mg) was very effective (Table 11) (Fig. 4).

Similar trend but a lesser magnitude was evident after 90 DAT. A concentration of 20 percent (1.54 mg) and 2h soaking (1.80 mg) was better. Higher concentrations

and durations were more effective. The total chlorophyll content was higher in the combination of seed treatment, foliar spray at vegetative and flowering stages (1.82mg). Among the extracts, spraying *calotropis* leaf extract was effective than other herbals in increasing the total chlorophyll content (1.78 mg) (Table 12).

4.3.6. Leaf area index

Higher leaf area index was observed in herbal extracts after 45 DAT compared to control and water soaking. A combination of seed treatment, foliar spray at vegetative and flowering stages (1.87) enhanced the leaf area index. Among the herbals, *calotropis* seed treatment followed by spraying at vegetative and flowering stage recorded higher leaf area index (2.15) the next best treatments were *ocimum* (2.12) and *morinda* (2.03) (Table 13).

After 90 DAT, the leaf area index was more in *calotropis* leaf extract (2.91) followed by *morinda* (2.84) and *ocimum* (2.79). Seed treatment followed by spraying at vegetative and flowering stage was more effective than control and water soaking (2.81). *Calotropis* with 2h soaking at 20% concentration was very effective (2.93 for 2 h and 2.80 for 20%).The other treatment combinations were less effective but better than water soaking and control (Table 14) (Fig 5).

4.3.7. Crop growth rate (CGR) ($gm^{-2}d^{-1}$)

The CGR was higher in herbal extracts compared to control and water soaking between 45-90 DAT. *Calotropis* performed better (1.78 g), followed by *morinda* (1.72 g). Seed treatment followed by foliar spray at vegetative and flowering, the effect was high in *calotropis* leaf extract (1.86) , followed by *morinda* (1.84 g) and *ocimum* (1.76 g). At 20% concentration and 2h soaking better results were observed. (Table 15) (Fig 6).

4.3.8. Relative growth rate (RGR) (mg g^{-1} d^{-1})

Between 45-90 DAT, among the herbs *calotropis* (24.7mg) and *morinda* (24.8mg) behaved equally. All the treatments were better than control (Table 16). Between the concentrations, 20% showed higher RGR (24.42) and soaking duration of 2 h was effective (24.52).

4.3.9. Net assimilation rate (NAR) (mg $cm^{-2}d^{-1}$)

Between 45-90 DAT, the NAR was maximum in *calotropis* (1.11mg) and the other two herbals were less effective but better than control. Seed treatment followed by spraying at vegetative and flowering stages (1.12mg) was very effective. With 20% concentration (0.97 mg) and 2 h of soaking (1.10 mg) the NAR was higher. (Table 17) (Fig 7).

4.3.10. Days to 50 % flowering (days)

Earliness was evident in *calotropis* (53.2) and *ocimum* (53.8) followed by *morinda* (54.1). Seed treatment either alone or in combination with spraying at vegetative and flowering resulted in early flowering in all the herbal extracts particularly *calotropis* (52.3). For this paramater 15% concentration (40.2) and 2 h of soaking (53.3) were effective in inducing earliness (Table 18).

4.3.11. Single fruit weight (g)

All the herbal treatments improved single fruit weight. In general, highest fruit weight was recorded in *calotropis* (63.8 g) and *morinda* (63.8g). Irrespective of herbals, 20% concentration increased the fruit weight (62.8g) compared to 15% (61.7g). Between the soaking durations, 2 h (64.5) was better than 1.50 h (60.7 g). A

combination of seed treatment followed by foliar spray at vegetative and flowering stage enhanced the fruit weight (67.5 g) compared to other combinations (Table 19).

4.3.12. Total number of fruits/ plant

Higher number of fruits per plant was observed in all herbal extracts. Among the herbals, the number of fruits were the highest in *calotropis* leaf extract treated plots (24.9) followed by *ocimum* leaf extract (24.8) and *morinda* (24.7). Among various treatment combinations, seed treatment followed by spraying at vegetative and flowering stage enhanced number of fruits (26.0). Among concentrations 20 %, produced more fruits (24.4) and a soaking duration of 2 h recorded highest number fruits (24.9) (Table 20).

4.3.13. Fruit yield per plot (kg)

Increase in the number of fruits per plant reflected on the fruit yield also. Maximum fruit yield was recorded with *calotropis* leaf extract (5.5 kg). A concentration of 20 % and 15 % behaved equally (5.4 kg). Among the treatment combinations, seed treatment with herbs followed by spraying at vegetative and flowering stage recorded the highest fruit yield (5.9, 5.7 and 5.2 kg for *morinda*, *calotropis* and *ocimum* respectively) (Table 21).

4.3.14. Number of seeds per fruit

All herbal treatments enhanced the number of seeds per fruit. *Calotropis* leaf extract (148) was very effective followed by *ocimum* (139) and *morinda* (127). Between concentrations, the effect was more at 20% (128) and between soaking durations, 2 h was better (137). A combination of herbal seed treatment followed by foliar application twice at vegetative and flowering increased the number of seeds (182) compared to other treatments (Table 22).

4.3.15. Seed yield per plant (g)

Seed yield per plant was highest in *calotropis* (17.9g) compared to *ocimum* (17.7g) and *morinda* (17.5g). Seed treatment followed by spraying at vegetative and flowering recorded higher seed yield (18.3g). Among the concentrations 20 % was effective (18.2g for *calotropis*, 17.8g for *ocimum* and 17.5 g for *morinda*). A soaking duration of 2h was better (17.6g). The other treatment combinations recorded higher seed yield compared to water (16.2) and control (15.7) (Table 23).

4.3.16. Seed yield plot-1 (g)

Maximum seed yield was recorded in *calotropis* leaf extract treated plots (40.1g). Between concentrations of 20 %, recorded higher seed yield (39.15g). Between soaking duration, 2 h (39.5g) was better than 1.50 h (38.9g). A combination of seed treatment followed by spraying at vegetative and flowering stage, recorded the highest seed yield (41.3g for *calotropis* 44.1g, 42.2 g for *morinda* and 41.1 g for *ocimum*). The other treatment combinations were better than water soaking and control (Table 24) (Fig 8).

4.3.17. Seed yield (kg/ha)

The seed yield/ ha had a similar trend as that of seed yield/plot (Table 25) (Fig 9).

4.3.18. Seed recovery (%)

The same trend similar to number of seeds was reflected on the recovery percentage also (0.96). Between concentrations, 20 % (0.90%) was better than 15% (0.89%). Between two soaking durations 2 h showed higher seed recovery (0.93%)

compared to 1.50 h (0.89%). Among the treatments seed treatment followed by foliar spray was better in improving the recovery of seeds (1.03) (Table 26).

4.3.19. 100 seed weight (g)

All herbal treatments enhanced 100 seed weight compared to control. It was the same in all the herbals (0.26g). Between the concentrations, higher seed weight was recorded in 20% (0.26g) and 2 h soaking duration was effective (0.27g). Among the treatments, a combination of seed treatment with spraying at vegetative and flowering stage with *calotropis* (0.30g) showed higher seed weight. (Table 27).

CHAPTER V

DISCUSSION

5.1. Standardization of eco-friendly seed treatment using herbal extracts for maintenance of vigour, viability, productivity and storage potential

Studies were initiated to identify the effect of different herbal extracts on seed vigour and viability maintenance. For ageing studies, duration of 6 days at a temperature 40 ± 1^{0}C and relative humidity 95±2% was necessary to reach the minimum seed certification standards in untreated seeds. Keeping this in view, treatments were imposed and seeds were aged to find out the effect of these treatments on biochemical and physiological properties and field performance. Standardization of concentration and duration of soaking was assessed using germination, seedling length and drymatter production as indicators.

5.1.1. Effect of herbal hydration-dehydration treatments on vigour and viability

In general, high relative humidity coupled with temperature would hasten the ageing process, ultimately affecting vigour, viability and production potential. High vigour seeds which are genetically pure, pathologically and physiologically sound would be preferred for enhancing productivity. Vigour and viability are interrelated factors and the loss of vigour precedes loss of viability (Roberts, 1972 and Gorecki and Harman, 1987 in peas and Ramamoorthy and Basu, 1997 in groundnut). Any treatment given for maintenance of viability should also take care of vigour during storage.

The seeds were subjected to soaking-drying, a form of hydration-dehydration treatment using three herbal extracts namely, *Calotropis gigantia, Morinda tinctorius*, *Ocimum basilicum*, to identify the efficacy as pre-sowing/ pre-storage seed treatments. A concentration of 20 % for 2 h was found to be effective in all the herbal extracts.

Morinda leaf extract was very effective both in artificial and naturally aged conditions followed by *calotropis* and *ocimum*.

5.1.2. Effect of herbal hydration-dehydration treatments on physiological and biochemical properties and their mode of action

The beneficial effect of hydration-dehydration on viability maintenance and field performance through formation of high energy compounds, increase DNA in the growing points, higher mitochondrial activity, respiratory rate, protein synthesis and maintenance of cellular integrity have been reported. (Henckel, 1961; Saha *et al.,* 1990; Dharmalingam and Basu, 1990; Smith and Cobb, 1991; Mandal *et al.,* 2000; Khan *et al.,* 2003; and De *et al.,* 2005). Other than simple hydration-dehydration, the impact of herbal extracts over untreated seeds have been attempted in several crops (Vanitha, 2005 in maize; Sujatha, 2006 in pulses) and the advantages have been reported.

Morinda leaf extract at 20 % concentration with 2 h soaking duration was very effective as it could be observed by the minimum value of electrical conductivity and lipid peroxidation both in fresh and aged seeds. The herbal extracts have more antioxidant compounds such as plant phenolics, including flavanoids and phcynylpropanoids (Rice-Evans *et al.,* 1996; Simon *et al.,* 1999; Phippen and Simon 2000). The major cause of seed ageing includes free radical mediated lipid peroxidation, enzyme inactivation or protein degradation, disruption of cellular membranes and damage to genetic (nucleic acid) material (Smith and Berjak, 1995; Walters, 1998 and Mc Donald, 1999). Cells are endowed with detoxifying enzymes and antioxidant compounds that could scavenge free radicals (Bernal-Lugo *et al.,* 2000 and Shelar, 2007). Lower speed of germination in untreated control and an increase in the same in *morinda* treated seeds followed by *calotropis* and *ocimum* might indicate the triggering of germination events as reported by Bailly (2004) and Mallach

et al., (2005).The beneficial effect of *morinda* in comparison with hydration with inorganics (Srimathi and Sujatha, 2006; Geetha *et al.,* 2007) could be attributed to the presence of growth regulators (Takeo yoshioka *et al.,* 2004) and micro and macro elements (Samina Kabir Khanzada *et al.,* 2008) in herbals.

In the present study, soaking with morinda or *calotropis* or *ocimum* at 20 % concentration for 2 h of soaking in comparison with water soaking could bring the beneficial effects in terms of membrane integrity indicated by lower electrical conductivity and lipid peroxidation in treated seeds. The results are in agreement with earlier findings using water or antioxidants (Pukacka, 1991; McDonald, 1999). However the effect was substantial in herbals. The higher activity of dehydrogenase in treated seeds is an indication of carboxylase catabolism and operation of repair mechanism affected by herbals. The inactivation of enzymes by free radicals as a reflection of ageing was also alleviated to a certain extent by herbal treatment as reported by Jeng and Sung, (1994) and Bhatia *et al.,* (2002).

5.2. Effect of herbal hydration-dehydration seed treatments and foliar spray on field performance

In view of the advantages realized in storage experiments by herbals on vigour and viability maintenance, studies were carried out to evaluate the field performance of treated seeds. The crop was raised with constant plant population per unit area during rabi, 2008 at AC & RI, Madurai, using tomato cv. PKM 1 seeds treated at 15% and 20% concentration each with 1.50 h and 2h of soaking duration and foliar spray (20%) at vegetative and flowering stage. In all the herbals, the physiological and yield contributing factors including drymatter was highest in seed treatment followed by foliar spray twice at vegetative and flowering stage. But the effect was always higher in *calotropis* combination (Plate 4).

As foliar spray these extracts can contribute for the supply of plant nutrients and other dissolved solutes through leaf cuticles which is partially permeable. This could also reduce water surface tension producing larger surface contact, the condition required for optimum nutrient assimilation (Mengel and Kirkby, 1987). In the present study, leaf area duration, crop growth rate, relative growth rate and net assimilation rate which might contribute for the increase in productivity were the highest in herbal treated seeds followed by foliar spray at both the growth phases compared to simple soaking or untreated control.

It is possible that the beneficial effect of *calotropis* could be attributed to growth promoting effect and nutritional components that would assist for better productivity namely an additive effect of hormones and nutrients. Similar benefits but at a lesser magnitude could be evident in other herbals *viz*., *morinda* and *ocimum*. The actual mechanism of these beneficial effects needs further studies. The positive effect observed in physiological parameters in treated seeds had an impact on productivity as observed through higher fruit weight, seed weight, fruit yield and seed yield against untreated. The reduced yield in control could be assigned to lack of vigour as reported by Harrison, 1966; Perry, 1977; Tekrony and Egli, 1977; Mandal, 1988 and Ramamoorthy and Basu, 1997). It could be inferred that seed treatment with *calotropis* at 20% concentration for 2h when combined with foliar spray at vegetative and flowering stage or the same combination with *morinda* or *ocimum* could effectively control the deterioration process simultaneously increasing the yield.

5.3. Effect of herbal hydration treatment on seed quality during storage

To assess the storability, the treated seeds were subjected to storage for three months using different containers namely gunny bag, polythene bag and cloth bag (December 2008 – March 2009) under ambient condition (mean temp. 27± 1^0C, RH 66±2%) at Agricultural College and Research Institute, Madurai. At the end of storage

period, only vigour parameters *viz*., germination, shoots length, root length and dry matter production were higher in the treated seeds (Plate 5). The electrical conductivity and lipid peroxidation showed minimum values with herbals and the performance of *morinda* was better than other herbals particularly with polythene bag compared to other containers, indicating the maintenance of vigour. The percentage germination was unaltered during this period.

CHAPTER VI

SUMMARY

The investigations were carried out in tomato cv. PKM 1 with the following objectives.

1. To identify the effect of herbal extracts as presowing / prestorage treatments on vigour and viability maintenance.

2. To assess the yield potential using herbal extract through seed treatment and foliar spray.

6.1. To identify the effect of herbal extracts on vigour and viability maintenance

Three herbal extracts *viz*., *Calotropis gigantia, Morinda tinctorius, Ocimum basilicum* were evaluated to assess their potentiality for pre-sowing and pre-storage seed treatments. Fresh seeds were treated with herbal leaf extracts, each at 15 and 20 percent concentrations with soaking durations of 1.50h and 2 h. The treated seeds were also subjected to artificial ageing for six days at a temperature 40 ± 1^{0}C and relative humidity 95±2%. A comparison of concentrations indicated 20 percent was effective. For soaking duration, 2h gave better results. Among the herbals, *morinda* was very effective under lab condition. The same trend as that of fresh seeds was observed in treated aged seeds. The advantageous effect of herbals as pre-storage treatments could be observed through higher germination, speed of germination, seedling length, dry weight and dehydrogenase activity. The lower electrical conductivity and lipid peroxidation could explain the operation of cellular repair and counteraction of lipid peroxidation.

6.2. Effect of herbal extracts through seed treatment and foliar spray on field performance

To assess the production potential the best combinations of treatments were forwarded to field studies. Among the herbals, *calotropis* and *morinda* were very effective. Both the herbal leaf extracts at 20% concentration with a soaking duration of 2 h outperformed other treatments. A combination of seed treatment with foliar spray (20%) at vegetative and flowering stages produced maximum effect. The advantageous effect of these treatments could be reflected in physiological and yield attributing factors *viz*., LAI, CGR, RGR, NAR, dry weight, fruit yield and seed yield.

6.3. To suggest a suitable inexpensive eco-friendly herbal treatment on seed storage

Herbal soaking of seeds for 2 h at a concentration of 20 % followed by drying, when stored at ambient conditions, for three months, using cloth bag, gunny bag and polythene bags revealed the superiority of polythene bags in general *morinda* leaf extract in particular for maintenance of intrinsic vigour as observed through lower electrical conductivity and lipid peroxidation though the percentage of germination was unaltered.

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Table 2. Effect of herbal leaf extracts on germination (%) and root length (cm) at different ageing conditions.

		Germination %				Root length (cm)			
		FT	**AA**	**NA**	**Mean**	**FT**	**AA**	**NA**	**Mean**
Control		86 (66.42)	72 (58.05)	76 (60.66)	78 (61.71)	6.7	5.1	5.8	5.9
Water		88 (68.03)	78 (62.03)	80 (63.43)	82 (64.69)	7.6	5.6	6.0	6.4
Calotropis	15%	91 (75.82)	85 (67.21)	86 (68.02)	87 (70.35)	9.8	8.0	8.8	8.9
	20%	94 (73.57)	86 (68.02)	88 (69.73)	89 (70.44)	10.2	8.4	9.1	9.3
	MEAN	92.5 (74.69)	86 (67.61)	87 (68.87)	88 (70.39)	10.0	8.2	9.0	9.1
Morinda	15%	92 (75.82)	84 (69.73)	88 (69.73)	88 (71.76)	10.6	8.0	9.8	9.3
	20%	94 (78.46)	86 (69.73)	88 (69.73)	89 (72.64)	12.8	8.2	11.5	10.5
	MEAN	93 (77.14)	85 (69.73)	88 (69.73)	89 (72.2)	11.7	8.1	10.7	10.2
Ocimum	15%	90 (73.56)	80 (65.65)	86 (68.02)	85 (69.07)	9.0	7.0	7.6	8.0
	20%	92 (71.56)	82 (64.89)	84 (66.42)	86 (67.62)	8.8	7.0	7.2	7.7
	MEAN	91 (74.35)	81 (65.27)	85 (67.22)	86 (68.34)	8.9	7.0	7.4	7.8
Mean		90 (72.13)	80 (53.93)	83 (65.98)	85 (64.46)	9.0	6.8	7.8	7.8

	FT	AA	NA	Mean	FT	AA	NA	Mean
15%	89	81	83	84	8.74	6.74	7.6	7.7
20%	90	81	83	85	9.22	6.86	7.92	8

	Germination (%)							Root length (cm)						
	H	**S**	**C**	**HS**	**SC**	**HC**	**HSC**	**H**	**S**	**C**	**HS**	**SC**	**HC**	**HSC**
SEd	(0.10)	(0.08)	(0.06)	(0.18)	(0.11)	(0.14)	(0.24)	0.12	0.09	0.07	0.20	0.13	0.63	0.28
CD(0.05)	(0.20**)	(0.16**)	NS	(0.36**)	NS	(0.1**)	(0.50**)	0.24**	0.12**	0.15**	0.41**	0.26**	0.33*	0.58**

FT: Fresh treated AA: Artificially aged NA: Naturally aged
*Significant at 5% level ** Significant at 1% level NS- Non Significant

Table 1. Standardization of accelerated ageing period

Ageing (days)	Germination (%)	Speed of germination	Root length (cm)	Shoot length (cm)	Drymatter production (mg 10 seedlings^{-1})
Control	86 (68.02)	11.62	9.16	7.59	26.0
1	82 (68.86)	11.49	8.47	7.0	22.1
2	78 (62.03)	11.10	7.86	6.6	21.6
3	77 (61.34)	11.20	7.43	6.1	20.2
4	75 (60.0)	10.48	6.98	5.6	19.4
5	74 (59.34)	10.13	6.6	5.3	18.3
6	72 (58.05)	10.00	6.01	5.1	18.1
7	66 (54.33)	9.20	5.4	4.7	15.8
8	54 (47.49)	8.09	5	4.01	12.4
9	48 (43.85)	7. 4	4.8	3.0	10.0
10	34 (35.66)	6. 05	4.0	2.6	9.8
SEd	(2.23)	0.35	0.29	0.28	2.8
CD(0.05)	(0.52**)	0.78**	0.64**	0.63**	0.0062**

* Significant at 1% level

Figures in parenthesis represent arcsine values

Table 4. Effect of herbal extracts on plant height (cm)

45 DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
ST	38.6	39.5	39.1	46.0	50.0	48.0	47.5	50.1	48.8	48.4	47.2	51.1	49.2	44.2	49.6	46.9	48.0	41.7	43.3	42.5	42.8	44.0	43.4	43.0	44.6
ST+V	38.2	39.2	38.7	54.5	55.0	54.8	55.5	56.5	56.0	55.4	46.0	48.0	47.0	49.0	50.6	49.8	48.4	45.3	48.1	46.7	49.7	49.9	49.8	48.3	47.7
ST+F	38.7	39.5	39.1	58.2	58.8	58.5	59.0	59.7	59.4	58.9	49.0	50.2	49.6	54.2	55.2	54.7	52.2	46.8	51.0	48.9	52.5	53.2	52.9	50.9	50.3
ST+V+F	38.5	39.6	39.1	64.0	67.7	65.9	62.8	68.2	65.5	65.7	54.0	54.2	54.1	55.0	55.7	55.4	54.7	52.3	54.2	53.3	56.1	57.0	56.6	54.9	53.6
Mean	38.4	39.2		52.2	53.9		52.6	54.5			46.9	48.3		48.1	49.8			44.8	46.9		47.8	48.4			
					M	53.0		M	53.6			M	47.6		M	49.0			M	45.9		M	48.1		
		M	38.8						M	53.3						M	48.3						M	47.0	

D	Water	Calotopis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	38.4	52.2	52.6	46.9	48.1	44.8	47.8	47.3
2 h	39.2	53.9	54.5	48.3	49.8	46.9	48.4	48.7

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	38.8	53	47.6	45.9	46.3
20%	38.8	53.6	49	48.1	47.4

	S	H	C	D	SH	SC	TD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.059	0.053	0.038	0.038	0.119	0.084	0.084	0.075	0.075	0.053	0.168	0.168	0.119	0.106	0.237
CD(0.05)	0.118**	0.106**	0.075**	0.075**	0.236**	0.167**	0.167**	0.149**	0.149**	0.106*	0.334**	0.334**	0.236**	0.211**	0.472**

S – Stages , H –Herbal, C – Concentration, D – Soaking duration, * - Significant at 5 percent level, ** - Significant at 1 percent level, NS- Non significant,

ST – Seed treatment, V – Foliar spray at vegetative stage, F – Foliar spray at flowering stage, M- Mean, GM – Grand mean

Table 5. Effect of herbal extract on plant height (cm)

90 DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7
ST	44.1	44.8	44.5	51.7	52.4	52.1	57.2	57.8	57.5	54.8	49.2	50.2	49.7	51.3	51.7	51.5	50.6	49.2	49.7	49.5	50.2	51.1	50.7	50.1	50.0
ST+V	43.8	44.2	44.0	54.7	61.2	58.0	64.2	68.3	66.3	62.1	54.2	57.0	55.6	54.0	58.0	56.0	55.8	53.1	56.1	54.6	54.0	58.5	56.3	55.4	54.3
ST+F	44.9	45.4	45.2	65.7	68.2	67.0	79.0	82.0	80.5	73.7	59.0	66.0	62.5	61.7	68.5	65.1	63.8	54.0	59.0	56.5	59.0	60.5	59.8	58.1	60.2
ST+V+F	43.6	44.9	44.3	82.1	84.3	83.2	86.2	89.3	87.8	85.5	76.3	76.2	76.3	78.5	84.3	81.4	78.8	67.0	68.5	67.8	74.5	76.1	75.3	71.5	70.0
Mean	44.0	44.6		59.6	62.0		66.1	68.2			56.5	58.6		57.8	61.2			53.4	55.4		56.3	58.0			
					M	60.8		M	67.1			M	57.6		M	59.5			M	54.4		M	57.1		
		M	44.3						M	64.0						M	58.5						M	55.8	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	44.0	59.6	66.1	56.5	57.8	53.4	56.3	56.2
2 h	44.6	62.0	68.2	58.6	61.2	55.4	58.0	58.3

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	44.3	60.8	57.6	54.4	54.3
20%	44.3	67.1	59.5	57.1	57.0

	S	H	C	D	H	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SE	0.08	0.08	0.05	0.05	0.17	0.12	0.12	0.11	0.11	0.08	0.24	0.24	0.17	0.15	0.34
CD(0.05)	0.17**	0.15**	0.11**	0.11**	0.34**	0.24**	0.24**	0.21**	0.21**	0.15**	0.48**	0.48**	0.34**	0.30**	0.68**

(Other details same as in table 4)

Table 6. Effect of herbal extracts on number of leaves

45 DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
ST	19.9	20.5	20.2	22.3	25.0	23.7	24.0	26.5	25.3	24.5	20.7	22.7	21.7	20.3	23.4	21.9	21.8	20.4	22.0	21.2	20.7	21.3	21.0	21.1	21.9
ST+V	18.5	19.4	19.0	27.3	28.5	27.9	27.8	29.3	28.6	28.2	22.4	23.0	22.7	23.1	24.1	23.6	23.2	20.9	21.6	21.3	22.0	23.9	23.0	22.1	23.1
ST+F	20.1	21.1	20.6	28.7	31.7	30.2	30.2	34.9	32.6	31.4	29.0	29.2	29.1	29.9	30.0	30.0	29.5	24.1	26.7	25.4	26.3	27.8	27.1	26.2	26.9
ST+V+F	20.5	20.9	20.7	41.2	43.0	42.1	41.7	44.5	43.1	42.6	32.9	33.5	33.2	37.3	39.3	38.3	35.8	30.9	31.1	31.0	33.5	35.8	34.7	32.8	33.0
Mean	19.5	20.1		27.6	29.3		28.4	30.7			24.7	25.4		25.8	27.1			23.0	24.0		24.2	25.5			
					M	28.5		M	29.6			M	25.0		M	26.4			M	23.5		M	24.8		
		M	19.8						M	29.0						M	25.7						M	24.2	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	19.5	27.6	28.4	24.7	25.8	23	24.2	24.7
2 h	20.1	29.3	30.7	25.4	27.1	24	25.5	26.0

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	19.8	28.5	25	23.5	24.2
20%	19.8	29.6	26.4	24.8	25.2

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.48	0.43	0.31	0.31	0.96	0.68	0.68	0.61	0.61	0.43	1.36	1.36	0.96	0.86	1.93
CD(0.05)	0.96**	0.86**	0.61**	0.61**	1.92**	1.36**	1.36*	1.21**	NS	NS	NS	NS	NS	NS	NS

(Other details same as in table 4)

Table 7. Effect of herbal extracts on number of leaves

90 DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
ST	31.2	32.4	31.8	36.7	38.0	37.4	36.3	42.0	39.2	38.3	33.0	34.3	33.7	32.8	36.5	34.7	34.2	30.8	33.5	32.2	32.1	34.0	33.1	32.6	34.2
ST+V	34.0	34.2	34.1	40.1	42.0	41.1	40.6	44.1	42.4	41.7	36.3	36.7	36.5	38.5	39.1	38.8	37.7	40.1	40.2	40.2	39.5	40.8	40.2	40.2	38.4
ST+F	32.4	32.6	32.5	42.5	44.9	43.7	43.0	45.0	44.0	43.9	38.7	39.9	39.3	40.3	41.3	40.8	40.1	38.8	40.7	39.8	41.0	41.7	41.4	40.6	39.2
ST+V+F	34.6	34.0	34.3	46.6	50.5	48.6	52.0	56.3	54.2	51.4	47.3	48.0	47.7	52.3	54.6	53.5	50.6	49.6	50.0	49.8	50.1	53.0	51.6	50.7	46.7
Mean	32.2	32.4		38.9	40.8		40.1	43.2			36.8	37.5		38.5	40.1			37.6	38.6		38.3	39.7			
					M	39.9		M	41.7			M	37.2		M	39.3			M	38.1		M	39.0		
		M	32.3						M	40.8						M	38.2						M	38.6	

	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	32.2	38.9	40.1	36.8	38.5	37.6	38.3	37.5
2 h	32.4	40.8	43.2	37.5	40.1	38.6	39.7	38.9

	Water	Calotropis	Morinda	Ocimum	Mean
15%	32.3	39.9	37.2	38.1	36.9
20%	32.3	41.7	39.3	39	38.1

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.25	0.22	0.16	0.16	0.49	0.35	0.35	0.31	0.31	0.22	0.70	0.70	0.49	0.44	0.99
CD(0.05)	0.49**	0.44**	0.31**	0.31**	0.98**	0.69**	0.69**	0.62**	0.62**	0.44**	1.39**	1.39**	NS	NS	1.96*

(Other details same as in table 4)

Table 8. Effect of herbal extracts on number of branches

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
ST	18.9	21.7	20.3	20.9	24.9	22.9	20.0	25.7	22.8	22.9	22.0	23.2	22.6	21.3	23.9	22.6	22.6	19.0	24.1	21.5	21.3	23.8	22.5	22.0	21.9
ST+V	19.8	19.5	19.6	22.8	25.3	24.1	24.9	29.3	27.1	25.6	20.1	24.5	22.3	23.0	25.4	24.2	23.3	19.9	25.9	22.9	22.7	24.8	23.7	23.3	22.9
ST+F	20.5	21.2	20.9	25.3	27.3	26.3	24.4	29.4	26.9	26.6	20.9	22.4	21.6	23.2	26.4	24.8	23.2	21.8	29.3	25.5	24.9	26.3	25.6	25.6	24.1
ST+V+F	20.9	22.8	21.9	25.9	28.7	27.3	29.1	31.9	30.5	28.9	25.6	26.5	26.0	23.9	27.1	25.5	25.8	23.4	27.9	25.7	27.3	29.5	28.4	27.0	25.9
Mean	19.8	20.8		22.7	25.0		23.4	27.0			21.5	23.0		22.0	24.3			20.6	25.2		23.0	24.6			
					M	23.9		M	25.2			M	22.3		M	23.2			M	22.9		M	23.8		
		M	20.3						M	24.5						M	22.7						M	23.3	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	19.8	22.7	23.4	21.5	22	20.6	23	21.9
2 h	20.8	25	27	23	24.3	25.2	24.6	24.3

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	20.3	23.9	22.3	22.9	22.4
20%	20.3	25.2	23.2	23.8	23.1

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.24	0.22	0.15	0.15	0.49	0.35	0.35	0.31	0.31	0.22	0.69	0.69	0.49	0.44	0.98
CD(0.05)	0.49**	0.44**	0.31**	0.31**	0.97**	0.69**	0.69**	0.62**	0.62**	NS	1.38**	1.38**	NS	0.87**	NS

(Other details same as in table 4)

Table 9. Effect of herbal extracts on dry matter (g)

45 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
ST	9.8	9.9	9.8	10.0	10.7	10.4	10.9	11.0	11.0	10.7	10.0	10.0	10.0	10.8	11.4	11.1	10.5	9.8	10.2	10.0	10.0	10.9	10.5	10.2	10.3
ST+V	9.8	10.3	10.1	9.9	10.2	10.1	10.8	11.3	11.0	10.5	10.2	10.3	10.2	9.8	11.3	10.6	10.4	10.0	10.3	10.1	10.0	11.1	10.6	10.4	10.3
ST+F	9.9	10.0	9.9	10.4	10.5	10.4	11.3	11.8	11.5	11.0	10.3	10.4	10.4	10.5	11.1	10.8	10.6	10.1	10.3	10.2	10.1	10.5	10.3	10.2	10.4
ST+V+F	10.0	10.1	10.0	11.1	11.5	11.3	12.5	12.6	12.5	11.9	11.6	12.2	11.9	11.0	11.5	11.2	11.6	10.2	10.3	10.3	10.2	10.5	10.3	10.3	10.9
Mean	9.9	10.0		10.2	10.5		11.0	11.3			10.4	10.5		10.4	11.0			10.0	10.2		10.0	10.5			
					M	10.4		M	11.2			M	10.4		M	10.7			M	10.1		M	10.3		
		M	9.9						M	10.8						M	10.6							10.2	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	9.90	10.20	11.00	10.40	10.40	10.00	10.00	10.27
2 h	10.00	10.50	11.30	10.50	11.00	10.20	10.50	10.57

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	9.9	10.4	10.4	10.1	10.2
20%	9.9	11.2	10.7	10.3	10.5

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.052	0.047	0.033	0.033	0.105	0.074	0.074	0.066	0.066	0.047	0.148	0.148	0.105	0.094	0.210
CD(0.05)	0.104**	0.093**	0.066**	0.066**	0.209**	0.147**	0.147**	0.132**	0.132*	0.093**	0.295**	NS	0.209**	0.186**	NS

(Other details same as in table 4)

Table 10. Effect of herbal extracts on dry weight (g)

90 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4
ST	28.0	28.0	28.0	31.7	33.7	32.7	31.8	33.0	32.4	32.5	31.7	32.8	32.3	30.6	31.9	31.2	31.7	30.5	33.2	31.8	30.0	31.4	30.7	31.3	30.9
ST+V	28.6	29.0	28.8	32.0	34.9	33.4	32.0	34.0	33.0	33.2	32.2	33.3	32.8	31.1	32.4	31.7	32.2	31.0	33.5	32.2	30.5	31.9	31.2	31.7	31.5
ST+F	29.2	30.1	29.7	32.5	35.4	33.9	32.2	34.9	33.5	33.7	32.7	33.8	33.2	31.1	33.5	32.3	32.7	31.5	33.7	32.6	30.8	32.9	31.8	32.2	32.1
ST+V+F	30.2	32.0	31.1	33.0	35.9	34.4	32.3	35.5	33.9	34.1	33.2	34.5	33.8	31.6	33.7	32.6	33.2	32.0	34.7	33.3	31.0	33.1	32.1	32.7	32.8
Mean	28.7	29.3		31.3	33.4		31.1	32.9			31.4	32.3		30.3	31.7			30.4	32.5		29.9	31.3			
					M	32.3		M	32.0			M	31.9		M	31.0			M	31.5		M	30.6		
		M	29.0						M	32.2						M	31.5						M	31.0	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	28.70	31.10	31.30	30.30	31.40	29.90	30.40	30.44
2 h	29.30	32.90	33.40	31.70	32.30	31.30	32.50	31.91

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	29.0	32.0	31.0	30.6	30.7
20%	29.0	32.3	31.9	31.5	31.2

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.052	0.047	0.033	0.033	0.105	0.074	0.074	0.066	0.066	0.047	0.148	0.148	0.105	0.094	0.210
CD(0.05)	0.104	0.093	0.066	0.066	0.209	0.147	0.147	0.132	0.132	0.093	0.295	0.295	0.209	0.186	0.417

(Other details same as in table 4)

Table11 . Effect of herbal extracts on Chlorophyll content (mg g^{-1})

45- DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
ST	2.22	2.25	2.24	2.24	2.37	2.30	2.35	2.57	2.46	2.38	2.25	2.41	2.33	2.66	2.67	2.66	2.49	2.39	2.58	2.48	2.31	2.46	2.38	2.43	2.39
ST+V	2.17	2.30	2.24	2.25	2.52	2.38	2.20	2.59	2.39	2.39	2.36	2.77	2.56	2.55	2.74	2.64	2.60	2.29	2.68	2.48	2.22	2.36	2.29	2.39	2.40
ST+F	2.24	2.27	2.26	2.26	2.66	2.46	2.54	2.92	2.73	2.60	2.52	2.69	2.61	2.29	2.73	2.51	2.56	2.41	2.74	2.57	2.44	2.69	2.56	2.57	2.49
ST+V+F	2.45	2.34	2.40	2.38	2.95	2.66	2.26	2.95	2.60	2.63	2.69	2.82	2.76	2.69	2.79	2.74	2.75	2.35	2.81	2.58	2.36	2.61	2.49	2.53	2.58
Mean	2.24	2.26		2.25	2.52		2.30	2.63			2.39	2.56		2.46	2.61			2.31	2.59		2.29	2.45			
					M	2.39		M	2.46			M	2.48		M	2.54			M	2.45		M	2.37		
		M	2.25						M	2.43						M	2.51						M	2.41	

D	Water	Calotopis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	2.24	2.25	2.30	2.39	2.46	2.31	2.29	2.32
2 h	2.26	2.52	2.63	2.56	2.61	2.59	2.45	2.52

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	2.25	2.39	2.48	2.45	2.39
20%	2.25	2.46	2.54	2.37	2.41

	T	H	C	D	TH	TC	TD	HC	HD	CD	THC	THD	TCD	HCD	THCD
SEd	0.017	0.015	0.011	0.011	0.034	0.024	0.024	0.021	0.021	0.015	0.048	0.048	0.034	0.030	0.067
CD(0.05)	0.033**	0.030**	NS	0.021**	0.067**	0.047**	0.047**	0.042**	0.042**	NS	0.095**	0.095**	NS	0.060**	NS

(Other details same as in table 4)

Table 12. Effect of herbal extracts on Chlorophyll content (mg g $^{-1}$)

90- DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
ST	1.21	1.12	1.17	1.85	2.17	2.01	1.78	2.18	2.10	2.05	1.19	2.50	1.85	1.69	2.47	2.08	1.96	1.45	1.84	1.65	1.67	2.41	2.04	1.84	1.76
ST+V	1.16	1.15	1.16	1.37	1.92	1.65	2.18	2.83	2.24	1.94	1.56	2.94	2.25	1.30	1.84	1.57	1.91	1.09	1.88	1.49	1.43	2.05	1.74	1.61	1.65
ST+F	1.10	1.17	1.14	2.03	2.12	2.08	1.63	2.18	2.13	2.10	1.63	2.45	2.04	1.94	2.02	1.98	2.01	2.13	2.26	2.20	1.03	2.05	1.54	1.87	1.78
ST+V+F	1.23	1.14	1.19	1.78	2.40	2.09	1.42	2.17	2.13	2.11	2.22	2.47	2.35	1.83	2.56	2.20	2.27	1.48	1.97	1.73	1.62	1.75	1.69	1.71	1.82
Mean	1.08	1.05		1.54	1.86		1.54	2.01			1.46	2.21		1.49	1.92			1.37	1.73		1.29	1.79			
					M	1.70		M	1.86			M	1.83		M	1.70			M	1.55		M	1.54		
		M	1.07						M	1.78						M	1.77						M	1.54	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	1.08	1.54	1.54	1.46	1.49	1.37	1.29	1.40
2 h	1.05	1.86	2.01	2.21	1.92	1.73	1.79	1.80

D	Water	Calotropis	Morinda	Ocimum	Mean
15%	1.07	1.70	1.83	1.55	1.54
20%	1.07	1.86	1.70	1.54	1.54

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.035	0.032	0.022	0.022	0.071	0.050	0.050	0.045	0.045	0.032	0.100	0.100	0.071	0.063	0.142
CD(0.05)	0.071**	0.063**	NS	0.045**	0.141**	0.100**	0.100**	0.089**	0.089**	0.063**	0.200**	0.200**	0.141**	0.126**	0.283**

(Other details same as in table 4)

Table 13 . Effect of herbal extracts on LAI

45 DAT

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
ST	1.12	1.21	1.17	1.30	1.84	1.57	1.19	2.45	1.82	1.70	1.37	2.17	1.77	1.78	2.18	1.98	1.88	1.45	1.84	1.65	1.03	2.05	1.54	1.59	1.58
ST+V	1.15	1.16	1.16	1.69	2.02	1.86	1.56	2.47	2.02	1.94	1.85	1.92	1.89	2.18	2.18	2.18	2.03	1.09	1.88	1.49	1.62	1.75	1.69	1.59	1.68
ST+F	1.14	1.10	1.12	1.83	2.47	2.15	1.63	2.50	2.07	2.11	1.42	2.12	1.77	1.63	2.17	1.90	1.84	1.48	1.97	1.73	1.43	2.05	1.74	1.73	1.70
ST+V+F	1.17	1.23	1.20	1.94	2.56	2.25	1.67	2.41	2.04	2.15	2.03	2.40	2.22	1.78	1.89	1.84	2.03	2.13	2.26	2.20	2.22	1.85	2.04	2.12	1.87
Mean	1.05	1.08		1.49	1.92		1.35	2.10			1.47	1.86		1.61	1.82			1.37	1.73		1.40	1.68			
					M	1.70		M	1.73			M	1.67		M	1.72			M	1.55		M	1.54		
		M	1.07						M	1.71						M	1.69						M	1.54	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	1.05	1.49	1.35	1.47	1.61	1.37	1.40	1.39
2 h	1.08	1.92	2.10	1.86	1.82	1.73	1.68	1.74

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	1.07	1.70	1.67	1.55	1.50
20%	1.07	1.73	1.72	1.54	1.52

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.024	0.021	0.015	0.015	0.047	0.033	0.033	0.030	0.030	0.021	0.067	0.067	0.047	0.042	0.095
CD(0.05)	0.047**	0.042**	NS	0.030**	0.094**	0.067**	NS	0.060**	0.060**	CD	0.133**	0.133**	0.094*	0.084**	0.188**

(Other details same as in table 4)

Table 14 . Effect of herbal extracts on LAI

90 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31
ST	2.32	2.50	2.41	2.47	3.20	2.84	2.74	3.20	2.97	2.90	2.45	2.70	2.58	3.10	3.30	3.20	2.89	2.40	2.87	2.64	3.10	3.14	3.12	2.88	2.77
ST+V	2.34	2.60	2.47	2.79	3.20	3.00	2.64	3.40	3.02	3.01	2.82	3.00	2.91	3.19	3.63	3.41	3.16	2.27	2.37	2.32	2.74	3.42	3.08	2.70	2.83
ST+F	2.31	2.38	2.35	3.23	3.80	3.52	3.21	3.45	3.33	3.42	2.70	3.02	2.86	3.20	3.28	3.24	3.05	2.98	3.21	3.10	2.79	2.98	2.89	2.99	2.95
ST+V+F	2.43	2.56	2.50	2.56	3.16	2.86	2.65	3.30	2.98	2.92	2.45	2.80	2.63	2.63	3.23	2.93	2.78	3.08	3.21	3.15	2.63	3.30	2.97	3.06	2.81
Mean	2.34	2.47		2.67	3.13		2.71	3.13			2.55	2.77		2.89	3.15			2.61	2.79		2.71	3.03			
					M	2.90		M	2.92			M	2.66		M	3.02			M	2.70		M	2.87		
		M	2.41						M	2.91						M	2.84						M	2.79	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	2.34	2.67	2.71	2.55	2.89	2.61	2.71	2.64
2 h	2.47	3.13	3.13	2.77	3.15	2.79	3.03	2.93

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	2.41	2.90	2.66	2.70	2.67
20%	2.41	2.92	3.02	2.87	2.80

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.024	0.021	0.015	0.015	0.047	0.033	0.033	0.030	0.030	0.021	0.067	0.067	0.047	0.042	0.095
CD(0.05)	0.047	0.042	0.030	0.030	0.094	0.067	0.067	0.060	0.060	0.042	0.133	0.133	0.094	0.084	0.188

(Other details same as in table 4)

Table15. Effect of herbal extracts on CGR ($gm^{-2}d$)

45-90 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
ST	1.50	1.49	1.49	1.79	1.89	1.84	1.72	1.84	1.78	1.81	1.66	1.75	1.70	1.69	1.83	1.76	1.73	1.69	1.74	1.72	1.71	1.79	1.75	1.73	1.69
ST+V	1.54	1.53	1.54	1.80	1.95	1.87	1.82	1.94	1.88	1.88	1.69	1.78	1.74	1.72	1.84	1.78	1.76	1.74	1.82	1.78	1.77	1.82	1.79	1.79	1.74
ST+F	1.59	1.66	1.62	1.80	2.01	1.90	1.81	2.00	1.90	1.90	1.71	1.86	1.78	1.75	1.91	1.83	1.81	1.71	1.89	1.80	1.76	1.81	1.79	1.79	1.78
ST+V+F	1.67	1.80	1.73	1.70	1.91	1.81	1.81	2.01	1.91	1.86	1.71	1.88	1.79	1.79	2.00	1.89	1.84	1.69	1.83	1.76	1.70	1.80	1.75	1.76	1.80
Mean	1.55	1.59		1.71	1.84		1.72	1.85			1.65	1.74		1.68	1.81			1.66	1.75		1.68	1.73			
					M	1.77		M	1.78			M	1.69		M	1.74			M	1.70		M	1.71		
		M	1.57						M	1.78						M	1.72						M	1.70	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	1.55	1.71	1.72	1.65	1.68	1.66	1.68	1.66
2 h	1.59	1.84	1.85	1.74	1.81	1.75	1.73	1.76

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	1.57	1.77	1.69	1.70	1.68
20%	1.57	1.78	1.74	1.71	1.70

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.017	0.016	0.011	0.011	0.035	0.025	0.025	0.022	0.022	0.016	0.049	0.049	0.035	0.031	0.070
CD(0.05)	0.035**	0.031**	NS	0.022**	0.069**	NS	0.049**	NS	0.044**	NS	NS	NS	NS	NS	NS

(Other details same as in table 4)

Table 16. Effect of herbal extracts on RGR (mg g^{-1} d^{-1})

45-90 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9
ST	23.3	23.1	23.2	23.9	24.1	24.0	25.8	26.4	26.1	25.1	23.6	24.3	24.0	24.8	24.3	24.5	24.2	24.8	24.7	24.8	24.8	25.0	24.9	24.8	24.3
ST+V	23.7	22.9	23.3	26.2	25.0	25.6	25.5	26.6	26.1	25.8	24.4	24.1	24.3	25.4	25.6	25.5	24.9	25.0	24.5	24.7	24.9	25.1	25.0	24.9	24.7
ST+F	24.0	24.6	24.3	25.1	25.8	25.5	25.2	26.8	26.0	25.7	23.7	23.4	23.6	24.5	25.9	25.2	24.4	25.2	26.0	25.6	24.9	25.8	25.3	25.5	25.0
ST+V+F	24.7	25.6	25.1	24.4	25.3	24.9	22.7	23.7	23.2	24.0	21.7	22.4	22.1	23.3	24.0	23.6	22.8	25.3	26.7	26.0	24.7	25.9	25.3	25.7	24.4
Mean	23.7	23.8		24.5	24.6		24.4	25.3			23.3	23.4		24.2	24.5			24.6	25.0		24.5	24.9			
					M	24.6		M	24.9			M	23.3		M	24.3			M	24.8		M	24.7		
		M	23.8						M	24.7						M	23.8						M	24.8	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	23.72	24.53	24.42	23.26	24.17	24.65	24.45	24.17
2 h	23.83	24.63	25.30	23.43	24.52	24.95	24.95	24.52

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	23.77	24.58	23.35	24.80	24.13
20%	23.77	24.86	24.35	24.70	24.42

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.074	0.066	0.047	0.047	0.148	0.105	0.105	0.094	0.094	0.066	0.210	0.210	0.148	0.133	0.297
CD(0.05)	0.148**	0.132**	0.093**	0.093**	0.295**	0.209**	0.209**	0.187**	0.187*	0.132**	0.418**	NS	0.295**	0.264**	0.591**

(Other details same as in table 4)

Table17. Effect of herbal extract on NAR (mg $cm^{-2}d^{-1}$)

45-90 DAT

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50h	2 h	M	1.50h	2 h	M	1.50h	2 h	M		1.50h	2 h	M	1.50h	2 h	M		1.50h	2 h	M	1.50h	2 h	M		
Control	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
ST	0.67	0.71	0.69	0.85	1.22	1.03	0.90	1.43	1.17	1.10	0.86	1.17	1.02	1.09	1.27	1.18	1.10	0.86	1.15	1.00	0.84	1.20	1.02	1.01	0.97
ST+V	0.70	0.74	0.72	1.08	1.34	1.21	1.00	1.53	1.27	1.24	1.10	1.19	1.14	1.25	1.40	1.32	1.23	0.75	1.05	0.90	0.97	1.20	1.09	0.99	1.05
ST+F	0.71	0.74	0.73	1.20	1.67	1.43	1.13	1.60	1.37	1.40	0.95	1.24	1.10	1.07	1.37	1.22	1.16	1.02	1.31	1.16	0.94	1.25	1.09	1.13	1.10
ST+V+F	0.78	0.88	0.83	1.09	1.54	1.32	0.97	1.46	1.22	1.27	1.03	1.26	1.14	0.99	1.23	1.11	1.13	1.24	1.46	1.35	1.12	1.27	1.19	1.27	1.12
M	0.67	0.72		0.95	1.26		0.90	1.31			0.89	1.08		0.98	1.16			0.88	1.10		0.88	1.09			
					M	1.10		M	1.11			M	0.98		M	1.07			M	0.99			0.98		
		M	0.70						M	1.11							1.03							0.99	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	0.67	0.95	0.90	0.89	0.98	0.88	0.88	0.88
2 h	0.72	1.26	1.31	1.08	1.16	1.10	1.09	1.10

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	0.70	1.10	0.98	0.99	0.94
20%	0.70	1.11	1.07	0.98	0.97

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.023	0.021	0.015	0.015	0.047	0.033	0.033	0.030	0.030	0.021	0.066	0.066	0.047	0.042	0.094
CD(0.05)	0.047	0.042	0.030	0.030	0.093	0.066	0.066	0.059	0.059	0.042	0.132	0.132	0.093	0.084	0.187

(Other details same as in table 4)

Table 18 . Effect of herbal extracts on 50% flowering (days)

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%		M	M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h			1.50 h	2 h	M	1.50 h	2 h	M		
Control	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3	55.3
ST	53.6	53.5	53.6	54.1	52.8	53.5	53.1	52.8	53.0	53.2	53.5	54.1	53.8	53.8	53.6	53.6	53.7	54.8	52.8	53.8	54.8	53.6	54.2	54.0	53.6
ST+V	54.1	53.4	53.8	53.5	51.3	52.4	53.7	51.3	52.5	52.5	54.1	53.5	53.8	54.9	53.4	53.4	53.6	54.7	51.3	53.0	54.7	53.6	54.2	53.6	53.3
ST+F	54.3	53.6	54.0	54.2	51.0	52.6	54.4	52.0	53.2	52.9	53.6	54.2	53.9	54.7	54.3	54.3	54.1	54.5	50.9	52.7	54.5	53.4	54.0	53.3	53.6
ST+V+F	53.9	53.8	53.9	53.5	51.2	52.4	53.2	51.2	52.2	52.3	53.8	53.5	53.7	53.8	53.9	53.9	53.8	53.7	51.2	52.5	53.7	53.1	53.4	52.9	53.2
Mean	54.2	53.9		54.1	52.3		53.9	52.5			54.1	54.1		54.5	54.1			54.6	52.3		54.6	53.8			
					M	53.2		M	53.2			M	54.1		M	54.1			M	53.4		M	54.2		
		M	54.1						M	53.2						M	54.1						M	53.8	

D	Water	Calotopis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	54.2	54.1	53.9	54.1	54.5	54.6	54.6	54.3
2 h	53.9	52.3	52.5	54.1	54.1	52.3	53.8	53.3

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	54.1	53.2	54.1	53.4	40.18
20%	54.1	53.2	54.1	54.2	40.38

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SED	0.022	0.019	0.014	0.014	0.043	0.031	0.031	0.028	0.028	0.019	0.061	0.061	0.043	0.039	0.087
CD(0.05)	0.043**	0.039**	0.027**	0.027**	0.087**	0.061**	0.061**	0.055**	0.05**5	0.039**	0.122**	0.122**	0.087**	0.077**	0.173**

(Other details same as in table 4)

Table 19. Effect of herbal extracts on single fruit weight (g)

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
ST	57.3	58.7	58.0	56.8	60.3	58.6	59.2	62.2	60.7	59.6	66.8	61.4	64.1	62.4	64.2	63.3	63.7	59.3	59.8	59.5	58.3	66.1	62.2	60.9	60.5
ST+V	59.9	62.1	61.0	58.3	66.5	62.4	61.3	62.2	61.8	62.1	61.8	64.5	63.2	62.9	68.7	65.8	64.5	59.8	64.1	62.0	59.1	65.2	62.2	62.1	62.4
ST+F	58.8	59.6	59.2	63.8	69.6	66.7	68.3	72.5	70.4	68.5	64.4	65.7	65.1	65.9	72.6	69.2	67.2	59.9	65.6	62.7	63.2	66.6	64.9	63.8	64.7
ST+V+F	61.3	65.2	63.2	63.1	78.3	70.7	70.2	78.6	74.4	72.6	65.2	68.8	67.0	61.7	74.0	67.8	67.4	59.7	72.9	66.3	63.5	70.2	66.9	66.6	67.5
Mean	58.7	60.3		59.6	66.2		63.0	66.3			62.9	63.3		61.8	67.1			59.0	63.7		60.0	64.9			
					M	62.9		M	64.7			M	63.1		M	64.5			M	61.3		M	62.5		
		M	59.5						M	63.8						M	63.8						M	61.9	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	58.70	59.60	63.00	62.90	61.80	59.00	60.00	60.71
2 h	60.30	66.20	66.30	63.30	67.10	63.70	64.90	64.54

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	59.50	62.90	63.10	61.30	61.70
20%	59.50	64.70	64.50	62.50	62.80

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SED	0.38	0.34	0.24	0.24	0.76	0.54	0.54	0.48	0.48	0.34	1.08	1.08	0.76	0.68	1.53
CD(0.05)	0.76**	0.68**	0.48**	0.48**	1.52**	1.07**	1.07**	NS	0.96**	NS	NS	2.15**	1.52**	1.36**	3.04**

(Other details same as in table 4)

Table 20. Effect of herbal extracts on number of fruits per plant

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3
ST	22.3	22.4	22.4	24.2	24.6	24.4	24.5	25.2	24.9	24.6	23	23.1	23.1	24	24.5	24.3	23.7	24.1	24.7	24.4	23.2	24.6	23.9	24.2	23.7
ST+V	22.2	22.4	22.3	23.8	24.7	24.3	24.2	27.4	25.8	25.0	24.3	26.3	25.3	24.3	25.7	25.0	25.2	24.2	24.9	24.6	24.1	25.3	24.7	24.6	24.3
ST+F	22.7	22.2	22.5	24.6	26.4	25.5	25.2	27.2	26.2	25.9	24.6	26	25.3	24.8	26.1	25.5	25.4	25.7	26.3	26.0	24	26	25.0	25.5	24.8
ST+V+F	22.7	22.8	22.8	24.2	26.1	25.2	28.2	28.8	28.5	26.8	26.5	27.1	26.8	28	27.2	27.6	27.2	26.3	27.9	27.1	26	29.1	27.6	27.3	26.0
Mean	22.4	22.4		23.8	24.8		24.9	26.2			24.1	25.0		24.7	25.2			24.5	25.2		23.9	25.5			
					M	24.3		M	25.5			M	24.6		M	24.9			M	24.9		M	24.7		
		M	22.4						M	24.9						M	24.7						M	24.8	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	22.4	23.8	24.9	24.1	24.7	24.5	23.9	24
2 h	22.4	24.8	26.2	25	25.2	25.2	25.5	24.9

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	22.4	24.3	24.6	24.9	24.1
20%	22.4	25.5	24.9	24.7	24.4

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.077	0.069	0.049	0.049	0.154	0.109	0.109	0.097	0.097	0.069	0.218	0.218	0.154	0.138	0.308
CD(0.05)	0.153**	0.137**	0.097**	0.097**	0.307**	0.217**	0.217**	0.194**	0.194**	0.137**	0.434**	0.434**	0.307**	0.274**	0.613**

(Other details same as in table 4)

Table 21. Effect of herbal extracts on fruit yield per plot (kg)

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
ST	5.2	5.4	5.3	5.4	5.7	5.6	5.4	5.6	5.5	5.5	5.5	5.5	5.5	5.4	5.5	5.5	5.5	5.2	5.5	5.3	5.5	5.7	5.6	5.5	5.4
ST+V	5.2	5.4	5.3	5.5	5.4	5.5	5.3	6.5	5.9	5.7	5.6	5.5	5.6	5.2	5.7	5.4	5.5	5.2	5.8	5.5	5.4	5.7	5.5	5.5	5.5
ST+F	5.2	5.5	5.4	5.3	6.4	5.8	5.7	5.8	5.7	5.8	5.4	5.6	5.5	5.6	5.6	5.6	5.5	5.7	5.8	5.8	5.4	5.6	5.5	5.6	5.6
ST+V+F	5.1	5.5	5.3	5.8	6.0	5.9	5.3	5.6	5.5	5.7	5.5	6.5	6.0	5.8	5.8	5.8	5.9	5.0	5.3	5.1	5.2	5.1	5.2	5.2	5.5
Mean	5.1	5.3		5.4	5.7		5.3	5.7			5.4	5.6		5.4	5.5			5.2	5.4		5.3	5.4			
					M	5.5		M	5.5			M	5.5		M	5.4			M	5.3		M	5.3		
		M	5.2						M	5.5						M	5.4						M	5.3	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	5.1	5.4	5.3	5.4	5.4	5.2	5.3	5.3
2 h	5.3	5.7	5.7	5.6	5.5	5.4	5.4	5.5

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	5.2	5.5	5.5	5.3	5.4
2O%	5.2	5.5	5.4	5.3	5.4

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.077	0.069	0.049	0.049	0.154	0.109	0.109	0.097	0.097	0.069	0.218	0.218	0.154	0.138	0.308
CD(0.05)	0.153**	0.137**	0.097**	0.097**	0.307**	0.217**	0.217**	0.194**	0.194**	0.137**	0.434**	0.434**	0.307**	0.274**	0.613**

(Other details same as in table 4)

Table 22. Effect of herbal extracts on number of seeds per fruit

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
ST	86	87	86	98	114	106	99	123	111	108	94	96	95	94	98	96	96	90	101	96	90	101	96	96	96
ST+V	85	86	86	118	129	124	131	177	154	139	124	135	130	126	135	130	130	96	99	98	96	99	98	98	113
ST+F	87	87	87	165	186	176	150	226	188	182	123	132	128	132	146	139	133	177	211	194	177	211	194	194	149
ST+V+F	86	88	87	210	238	224	215	241	228	226	148	174	161	210	234	222	192	223	228	226	223	228	226	226	182
Mean	85	86		135	150		136	170			115	124		129	139			134	145		134	145			
					M	143		M	153			M	119		M	134			M	139		M	139		
		M	86						M	148						M	127						M	139	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	85	135	136	115	129	134	134	124
2 h	86	150	170	124	139	145	145	137

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	86	143	119	139	122
2O%	86	153	134	139	128

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.311	0.278	0.197	0.197	0.623	0.440	0.440	0.394	0.394	0.278	0.881	0.881	0.623	0.557	1.245
CD(0.05)	0.620**	0.554**	0.392**	0.392**	1.239**	0.876**	0.876**	0.784**	0.784**	0.554**	1.753**	1.753**	1.239**	1.108**	2.479**

(Other details same as in table 4)

Table 23 . Effect of herbal extracts on Seed yield per plant (g)

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7
ST	15.9	16.0	15.9	17.6	17.8	17.7	18.7	19.6	19.2	18.4	16.7	17.1	16.9	17.3	17.4	17.3	17.1	16.4	17.3	16.9	16.5	18.3	17.4	17.1	17.1
ST+V	16.1	16.2	16.2	17.3	17.8	17.5	18.2	18.9	18.6	18.0	16.7	17.5	17.1	17.8	17.8	17.8	17.4	18.4	18.9	18.7	17.7	17.9	17.8	18.2	17.5
ST+F	16.4	16.6	16.5	17.7	18.7	18.2	17.8	18.9	18.4	18.3	18.8	18.5	18.7	18.0	18.0	18.0	18.3	18.3	18.9	18.6	19.1	19.0	19.0	18.8	18.0
ST+V+F	16.8	16.9	16.8	18.2	18.7	18.5	19.0	19.9	19.5	19.0	19.0	18.7	18.9	18.8	19.0	18.9	18.9	17.9	17.9	17.9	19.0	19.1	19.0	18.5	18.3
Mean	16.2	16.3		17.3	17.7		17.9	18.6			17.4	17.5		17.5	17.6			17.3	17.8		17.6	18.0			
					M	17.5		M	18.2			M	17.4		M	17.5			M	17.5		M	17.8		
		M	16.2						M	17.9						M	17.5						M	17.7	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	16.20	17.30	17.90	17.40	17.50	17.30	17.60	17.31
2 h	16.30	17.70	18.60	17.50	17.60	17.80	18.00	17.64

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	16.20	17.50	17.40	17.50	17.2
20%	16.20	18.20	17.50	17.80	17.4

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SED	0.20	0.18	0.13	0.13	0.40	0.29	0.29	0.26	0.26	0.18	0.57	0.57	0.40	0.36	0.81
CD(0.05)	0.40**	0.36**	0.25*	0.25**	0.80**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

(Other details same as in table 4)

Table 24. Effect of herbal extracts on seed yield per plot (g)

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3
ST	37.4	37.6	37.5	37.6	37.8	37.7	38.0	38.2	38.1	37.9	37.6	38.2	37.9	38.2	38.6	38.4	38.2	37.9	38.0	38.0	37.6	37.9	37.8	37.9	37.9
ST+V	37.5	37.8	37.7	38.8	39.7	39.3	39.3	40.0	39.6	39.4	38.4	38.8	38.6	39.3	39.7	39.5	39.1	38.2	38.7	38.4	38.3	38.7	38.5	38.5	38.7
ST+F	37.7	37.7	37.7	40.1	42.3	41.2	41.3	42.8	42.1	41.6	39.6	40.0	39.8	40.1	41.1	40.6	40.2	38.8	39.4	39.1	38.9	40.1	39.5	39.3	39.7
ST+V+F	37.7	37.7	37.7	42.5	44.5	43.5	43.9	45.7	44.8	44.1	40.1	43.1	41.6	42.4	43.2	42.8	42.2	40.1	40.7	40.4	41.1	42.3	41.7	41.1	41.3
Mean	37.5	37.6		39.3	40.3		40.0	40.8			38.6	39.5		39.5	40.0			38.5	38.8		38.6	39.3			
					M	39.8		M	40.4			M	39.0		M	39.7			M	38.6		M	38.9		
		M	37.6						M	40.1						M	39.4						M	38.8	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	37.50	39.30	40.00	38.60	39.50	38.50	38.60	38.86
2 h	37.60	40.30	40.80	39.50	40.00	38.80	39.30	39.47

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	37.60	39.80	39.00	38.60	38.75
20%	37.60	40.40	39.70	38.90	39.15

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.14	0.12	0.09	0.09	0.28	0.20	0.20	0.18	0.18	0.12	0.39	0.39	0.28	0.25	0.56
CD(0.05)	0.28**	0.25**	NS	0.18**	NS	0.39**	0.39**	0.35**	NS	NS	NS	NS	NS	NS	NS

(Other details same as in table 4)

Table 25. Effect of herbal extracts on Seed yield kg/ha

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4
ST	41.3	42.5	41.9	49.7	51.4	50.6	49.6	60.4	55.0	52.8	47.2	49.1	48.2	50.8	62.2	56.5	52.3	44.2	47.4	45.8	48.0	57.0	52.5	49.2	49.0
ST+V	41.6	42.8	42.2	50.0	54.8	52.4	62.8	74.6	68.7	60.5	53.0	61.0	57.0	47.0	74.2	60.6	58.8	50.6	60.9	55.7	44.1	67.2	55.7	55.7	54.3
ST+F	41.8	43.5	42.7	60.2	64.6	62.4	66.7	78.8	72.8	67.6	62.6	70.0	66.3	62.7	73.3	68.0	67.1	57.2	74.8	66.0	67.0	70.2	68.6	67.3	61.2
ST+V+F	42.0	43.8	42.9	75.0	75.9	75.4	80.3	87.0	83.7	79.6	77.4	82.0	79.7	80.6	81.7	81.1	80.4	73.7	82.4	78.1	77.6	80.6	79.1	78.6	70.4
Mean	41.6	42.8		55.3	57.6		60.2	68.4			56.3	60.7		56.5	66.6			53.4	61.4		55.6	63.3			
					M	56.4		M	64.3			M	58.5		M	61.5			M	57.4		M	59.5		
		M	42.2						M	60.4						M	60.0						M	58.4	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	41.63	55.27	60.17	56.33	56.49	53.43	55.62	54.13
2 h	42.81	57.62	68.45	60.71	66.57	61.39	63.29	60.12

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	42.2	56.44	58.52	57.41	53.64
20%	42.20	64.31	61.53	59.45	56.87

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.12	0.11	0.08	0.08	0.25	0.17	0.17	0.16	0.16	0.11	0.35	0.35	0.25	0.22	0.49
CD(0.05)	0.24**	0.22**	0.15**	0.15**	0.49**	0.34**	0.34**	0.31**	0.31**	0.22**	0.69**	0.69**	0.49*	0.44*	0.98**

(Other details same as in table 4)

Table 26. Effect of herbal extracts on no of seeds recovery %

Treatment	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	0.76	0.76	0.76	0.76	0.76	0.76	0.8	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
ST	0.76	0.77	0.77	0.88	0.89	0.89	0.9	0.91	0.90	0.89	0.88	0.89	0.89	0.88	0.9	0.89	0.89	0.87	0.89	0.88	0.89	0.91	0.90	0.89	0.86
ST+V	0.78	0.78	0.78	0.92	0.97	0.95	0.9	0.98	0.95	0.95	0.87	0.97	0.92	0.91	0.93	0.92	0.92	0.89	0.93	0.91	0.88	0.95	0.92	0.91	0.89
ST+F	0.78	0.79	0.79	1	1.04	1.02	1.1	1.17	1.14	1.08	0.92	0.97	0.95	0.82	0.99	0.91	0.93	0.91	0.97	0.94	0.92	0.95	0.94	0.94	0.93
ST+V+F	0.79	0.8	0.80	1.05	1.12	1.09	1.2	1.26	1.21	1.15	1	1.21	1.11	1.14	1.19	1.17	1.14	1	1.17	1.09	0.99	1.01	1.00	1.04	1.03
Mean	0.77	0.78		0.92	0.96						0.89	0.96		0.90	0.95			0.89	0.94		0.89	0.92			
					M	0.94		M	0.99			M	0.92		M	0.93			M	0.92			0.90		
		M	0.78						M	0.96						M	0.93					M	M	0.91	

D	Water	Calotropis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	0.77	0.92	0.98	0.89	0.90	0.89	0.89	0.89
2 h	0.78	0.96	1.02	0.96	0.95	0.94	0.92	0.93

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	0.78	0.94	0.92	0.92	0.89
20%	0.78	0.99	0.93	0.90	0.90

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.004	0.003	0.002	0.002	0.007	0.005	0.005	0.005	0.005	0.003	0.010	0.010	0.007	0.006	0.014
CD(0.05)	0.007**	0.006**	0.004**	0.004**	0.014**	0.010**	0.010**	0.009**	0.009**	NS	0.020**	0.020**	0.014**	0.013**	0.028**

(Other details same as in table 4)

Table 27. Effect of herbal extracts on 100 Seed weight (g)

Treatments	Water			Calotropis							Morinda							Ocimum							
				15%			20%			M	15%			20%			M	15%			20%			M	GM
	1.50 h	2 h	M	1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		1.50 h	2 h	M	1.50 h	2 h	M		
Control	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
ST	0.22	0.22	0.22	0.25	0.25	0.25	0.26	0.27	0.27	0.26	0.24	0.25	0.24	0.24	0.27	0.25	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.25	0.24
ST+V	0.22	0.24	0.23	0.26	0.27	0.26	0.27	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.27	0.27	0.26	0.25	0.26	0.26	0.27	0.27	0.27	0.26	0.26
ST+F	0.22	0.24	0.23	0.26	0.29	0.27	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.26	0.27	0.27	0.28	0.27	0.28	0.28	0.25	0.27	0.26	0.27	0.26
ST+V+F	0.22	0.26	0.24	0.29	0.30	0.29	0.29	0.32	0.31	0.30	0.26	0.27	0.27	0.28	0.29	0.28	0.27	0.26	0.28	0.27	0.28	0.28	0.28	0.28	0.27
Mean	0.22	0.23		0.25	0.26		0.26	0.27			0.25	0.25		0.25	0.26			0.25	0.26		0.25	0.26			
					M	0.26		M	0.27			M	0.25			0.26			M	0.26		M	0.26		
		M	0.23						M	0.26						M	0.26						M	0.26	

D	Water	Calotopis		Morinda		Ocimum		Mean
		15%	20%	15%	20%	15%	20%	
1.50h	0.22	0.25	0.26	0.25	0.25	0.25	0.25	0.25
2 h	0.23	0.26	0.27	0.25	0.26	0.26	0.26	0.27

C	Water	Calotropis	Morinda	Ocimum	Mean
15%	0.23	0.26	0.25	0.26	0.25
20%	0.23	0.27	0.26	0.26	0.26

	S	H	C	D	SH	SC	SD	HC	HD	CD	SHC	SHD	SCD	HCD	SHCD
SEd	0.005	0.004	0.003	0.003	0.009	0.007	0.007	0.006	0.006	0.004	0.013	0.013	0.009	0.008	0.019
CD(0.05)	0.009**	0.008**	0.006**	0.006**	0.019**	0.013**	0.013**	0.012**	0.012**	0.008**	0.026**	0.026**	0.019**	0.017**	0.037**

(Other details same as in table 4)

ANNEXURE I

Weather data of the cropping period 2008 – 2009

Months	**Rainfall (mm)**	**Mean temperature (^{0}C)**		**Relative humidity (%)**	**Pan evaporation (mm day^{-1})**	**Sunshine (hr day^{-1})**	**Wind velocity (km hr^{-1})**
		Max.	Min.				
December	26.6	29.0	20.5	80.5	2.88	6.3	2.4
January	4.2	29.6	19.6	79.0	3.60	8.3	2.9
February	-	31.8	19.3	79.8	4.03	10.1	2.1
March	-	35.1	21.4	77.6	4.80	8.1	1.1
April	65.6	35.3	23.8	74.8	4.75	7.6	1.1

ANNEXURE II
Plan and layout of experimental field

Outs

Calotropis			
Replication I			
ST 20% 2h	W+V 2h	W+V+F 1.50h	ST+F 15% 2h
ST+V 15% 1.50h	ST+V 20% 2h	C	W+V 1.50h
C	W 1.50h	ST+V+F 15% 2h	ST 20% 1.50h
ST 15% 2h	W+V+F 2h	ST+V 20% 1.50h	W+F 2h
ST+F 20% 1.50h	C	ST+V+F 15% 1.50h	ST+V 15% 2h
W+F 1.50h	ST+F 20% 1.50h	W 2h	ST+V+F 20% 2h
ST 15% 1.50h	ST+V+F 20% 1.50h	C	ST+F 20% 2h
Replication II			
ST+F 20% 1.50h	C	ST 20% 2h	W+V+F 1.50h
W+V+F 1.50h	ST+V+F 20% 2h	ST+V 15% 2h	ST+F 15% 1.50h
ST 15% 1.50h	W+V 1.50h	C	W+V 2h
W 1.50h	ST+F 15% 1.50h	ST+F 20% 2h	C
C	W+F 1.50h	ST 15% 2h	W+F 2h
ST+V+F 20% 1.50h	W 2h	ST+V+F 15% 1.50h	ST 20% 2h
ST+V 20% 2h	ST+V+F 15% 2h	ST+V 15% 1.50h	ST+V+F 15% 1.50h

Irrigation channel (50 cm)

Morinda			
Replication I			
ST+V 15% 1.50h	ST+F 15% 1.50h	W 2h	ST+F 20% 2h
ST+V+F 20% 2h	W+V+F 2h	W 1.50h	C
W+V 1.50h	C	ST+V+F 15% 1.50h	W+V+F 1.50h
ST+V 20% 2h	ST 15% 2h	W+F 1.50h	C
W+F 2h	ST+V+F 20% 1.50h	ST+V 20% 1.50h	ST 20% 1.50h
ST 15% 1.50h	W+V 2h	C	ST+V 15% 2h
ST 20 % 2h	ST+F 20% 1.50h	ST+F 15% 2h	ST+V+F 15% 2h
Replication II			
C	ST+V+F 20% 2h	ST+V 20% 1.50h	W+F 1.50h
W+F 2h	C	ST+F 20% 2h	ST+F 20% 1.50h
ST+V 20% 1.50h	W+V 1.50h	ST+V 20% 2h	ST 15% 2h
W+V 2h	ST+V+F 15% 2h	ST 20% 1.50h	W 1.50h
ST 20% 1.50h	W+V+F 2h	C	ST+V+F 20% 1.50h
W+V+F 2h	ST+F 15% 1.50h	ST 15% 1.50h	C
ST+F 15% 2h	ST+V 15% 1.50h	ST+V 15% 2h	W 2h

Irrigation channel (50 cm)

Ocimum			
Replication I			
ST+V 15% 1.50h	W+V+F 1.50h	C	ST 15% 1.50h
W+V 2h	W 2h	ST+F 20% 1.50h	ST+F 15% 1.50h
C	ST+V 20% 2h	ST+V+F 20% 2h	W+V 1.50h
W+F 2h	ST 20% 2h	C	ST+F 20% 2h
ST 15% 2h	ST+V 15% 2h	W+F 1.50h	ST+V+F 15% 2h
C	W+V+F 2h	ST+F 15% 2h	W 1.50h
ST 20% 1.50h	ST+V+F 20% 1.50h	ST+V 20% 1.50h	ST+V+F 15% 1.50h
Replication II			
C	ST 15% 2h	W+F 1.50h	ST+V 15% 1.50h
ST+F 20% 1.50h	W+V 2h	ST+F 15% 2h	W+V+F 2h
ST 15% 1.50h	ST+V 20% 2h	ST+V+F 20% 1.50h	W+V 1.50h
C	ST 20% 2h	ST+F 20% 2h	ST+V+F 15% 2h
ST+V 15% 2h	W+F 2h	W 2h	ST 20% 1.50h
W 1.50h	ST+F 15% 1.50h	C	ST+V+F 20% 2h
ST+V 20% 1.50h	C	ST+V+F 15% 1.50h	W+V+F 1.50h

Outs

C-Control, W-Water treatment, ST-Seed treatment, V-Foliar spray at vegetative stage, F-Foliar spray at flowering stage,

ANNEXURE III

Characteristic features of tomato cv. PKM 1

Parents		An induced mutant from Annangi tomato
Duration	:	135 days
Plat height (cm)	:	45- 60cm
Days to 50% flowering	:	45-50 days
First harvest		75 - 85 Days
Fruits	:	Capsicum red color, with green shoulder
Shape		Oval
Weight		50 - 60 g
Number of fruits per plant		30/ plant
Fruit yield		30 to 35 tone/ha

ANNEXURE IV

Physical – chemical characteristics of the experimental plot (Initial soil status)

	Particulars	**Analytical data**
A.	**Mechanical composition (Piper, 1966)**	
	Clay (%)	19.20
	Silt (%)	10.80
	Fine sand (%)	24.70
	Coarse sand (%)	45.60
	Textural class	Sandy loam
B.	**Physical properties**	
	Bulk density (g cc^{-1})	1.57
	Pore space (%)	37.10
	Particle density (g cm^{-3})	2.37
	Infiltration rate (cm hr^{-1})	3.55
C.	**Chemical composition**	
	Sod pH (1:2 soil water suspension)	7.40
	Electrical conductivity (dSm-1) (1:2 soil water suspension)	0.39
	Available N (kg ha^{-1}) (Subbiah and Asija, 1956)	182.00
	Available P (kg ha^{-1}) (Olsen *et al.,* 1954)	8.60
	Available K (kg ha^{-1}) (Stanford and English, 1949)	290.90
	Organic carbon (%) (Jackson, 1973)	0.50

Fig 8. Effect of herbal extracts on seed yield (g/plot)

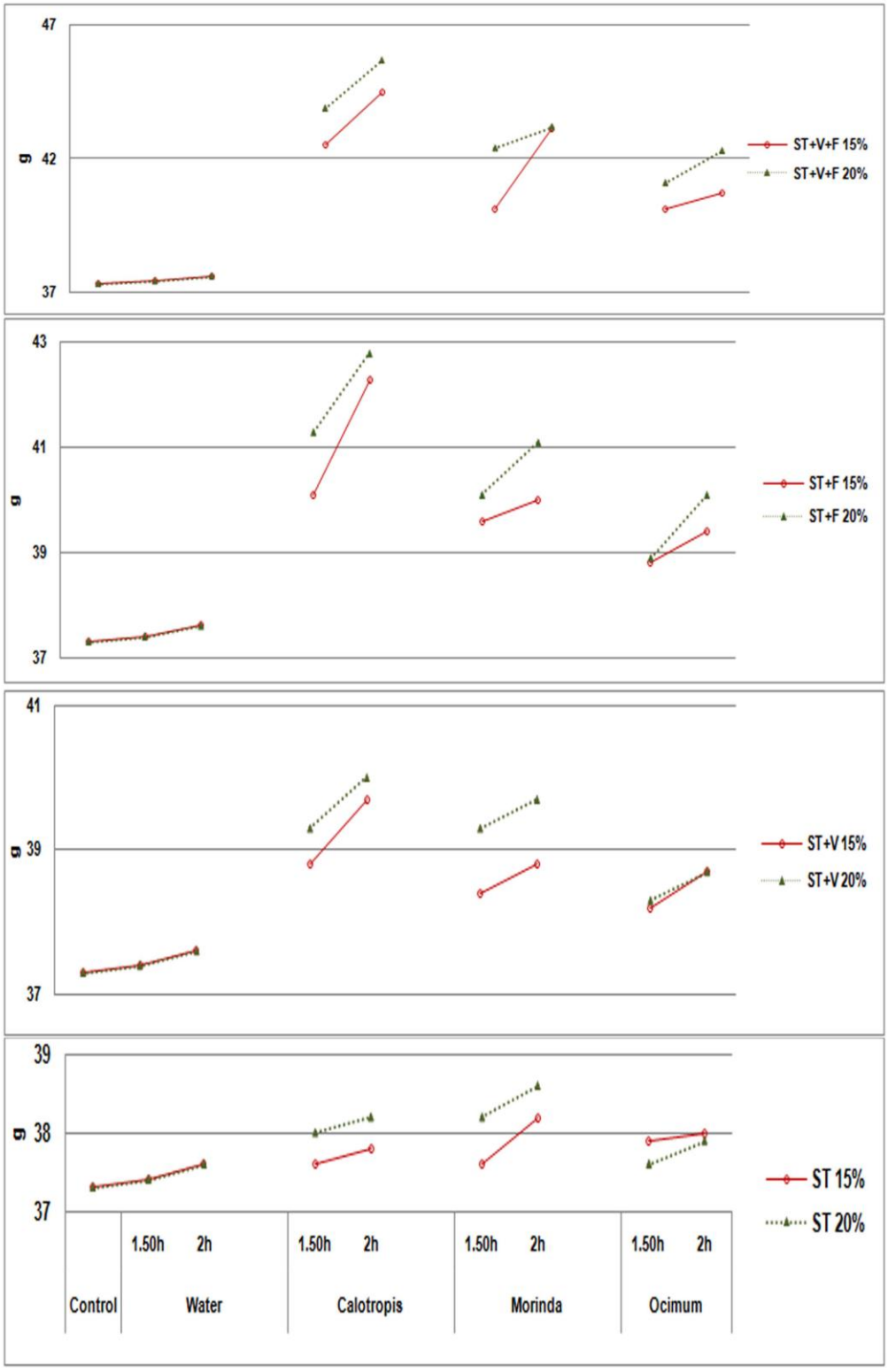


Fig 9. Effect of herbal extracts on seed yield

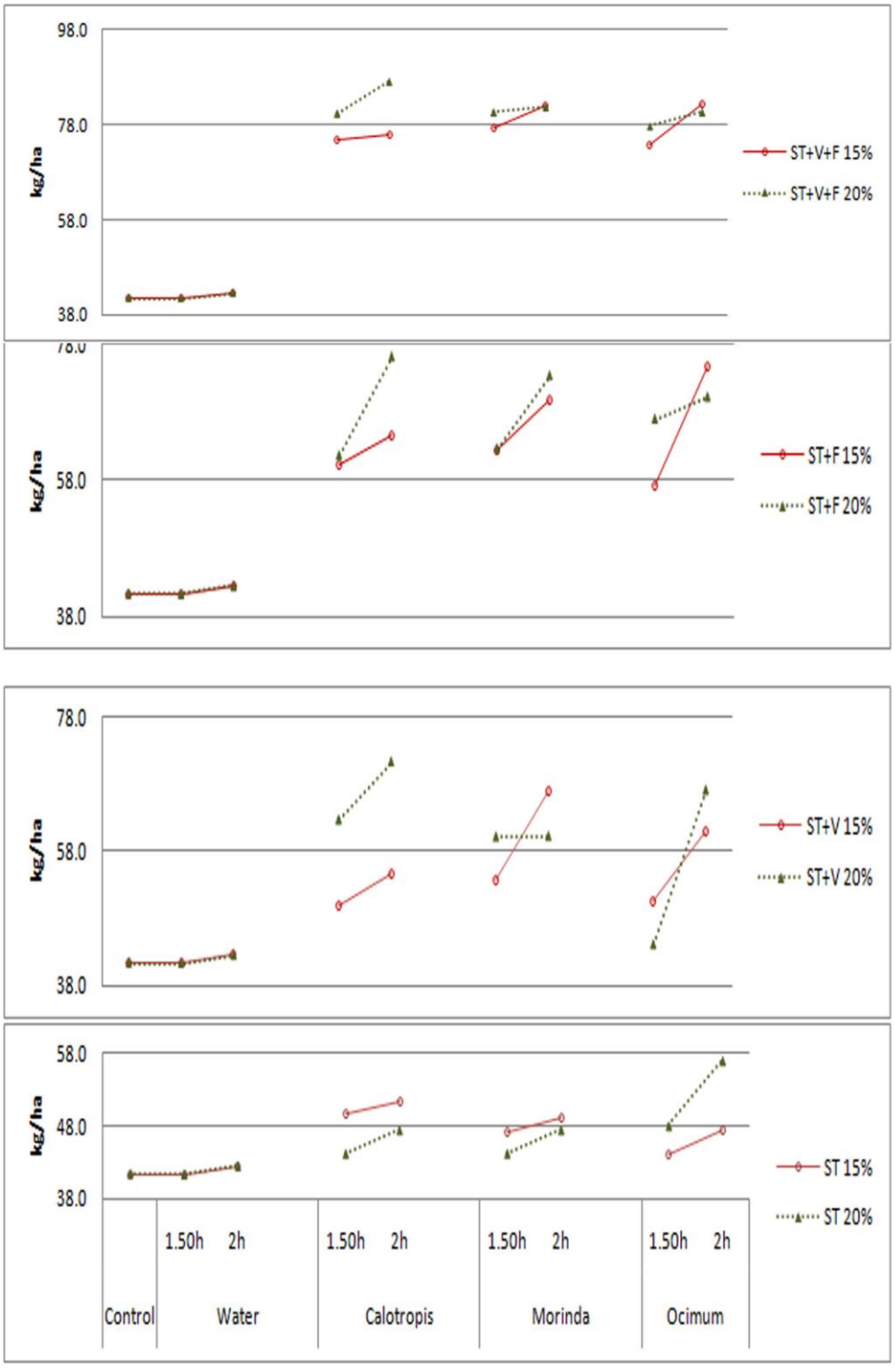


Fig. 2. Effect of herbal extracts and containers on seed quality attributes

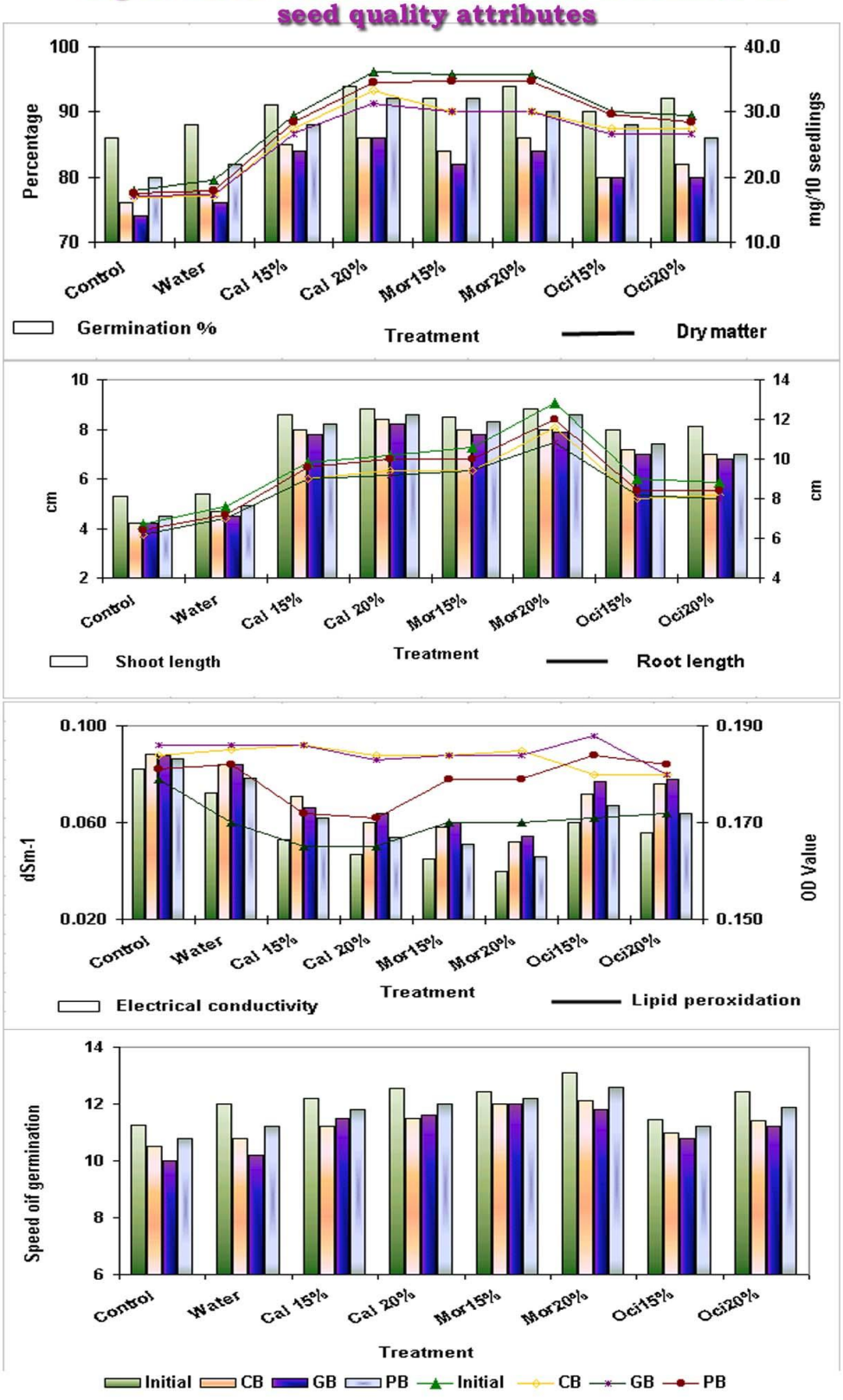


Fig.3. Effect of herbal extracts on quality attributes in different ageing conditions

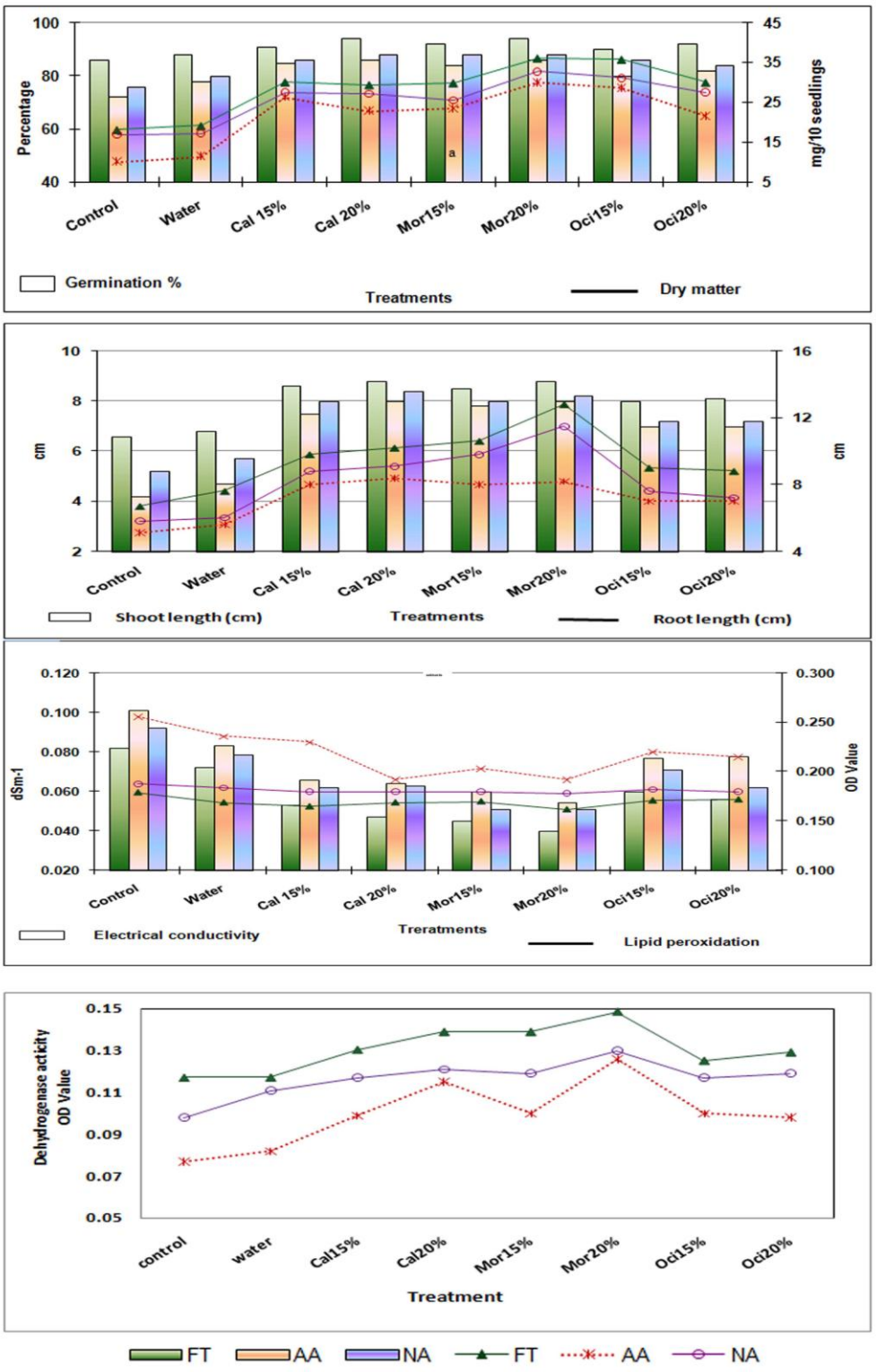


Fig 7. Effect of herbal extracts on NAR (45-90 DAT)

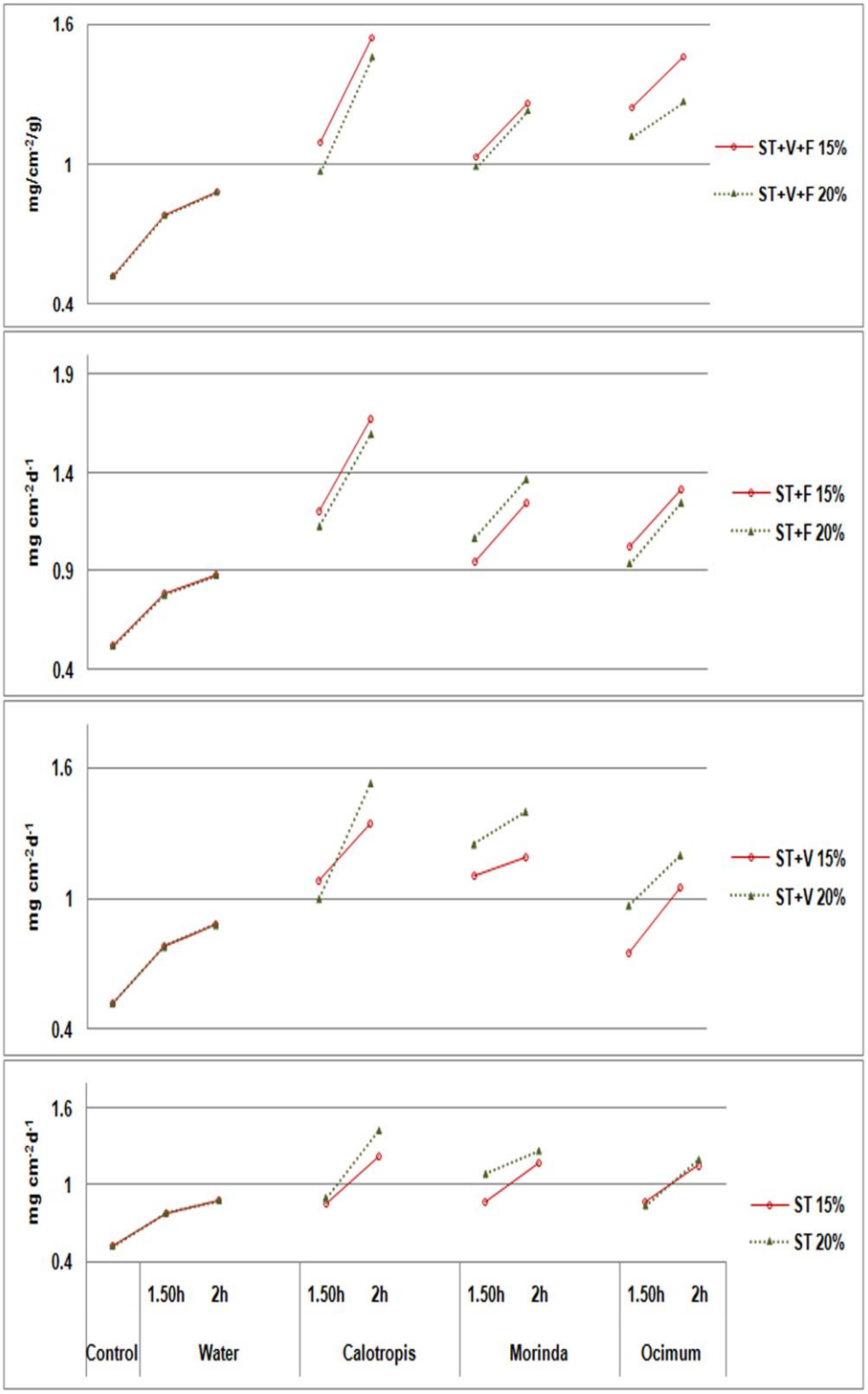


Fig 5. Effect of herbal extracts on LAI (90 DAT)

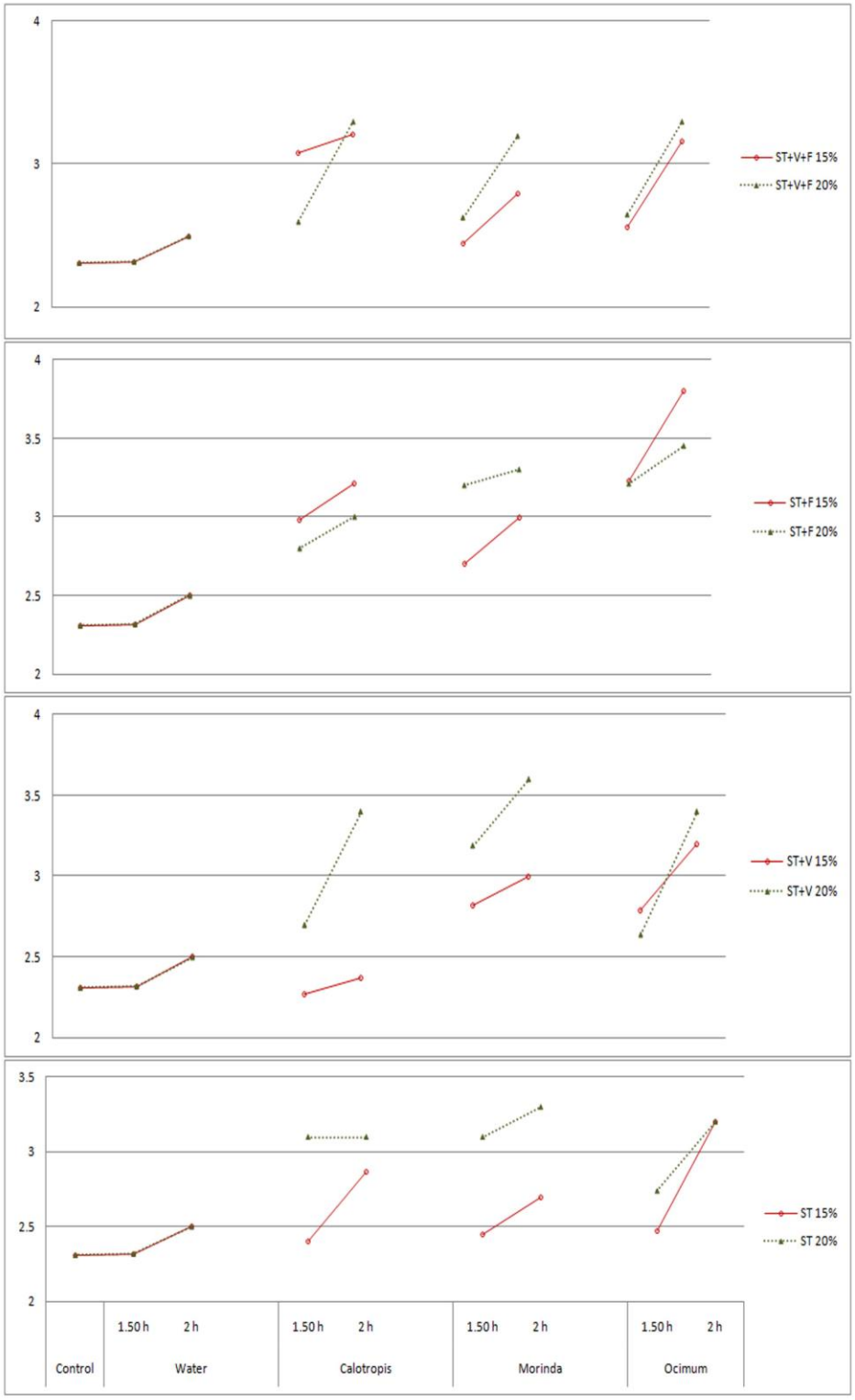


Fig 6. Effect of herbal extracts on CGR (45-90 DAT)

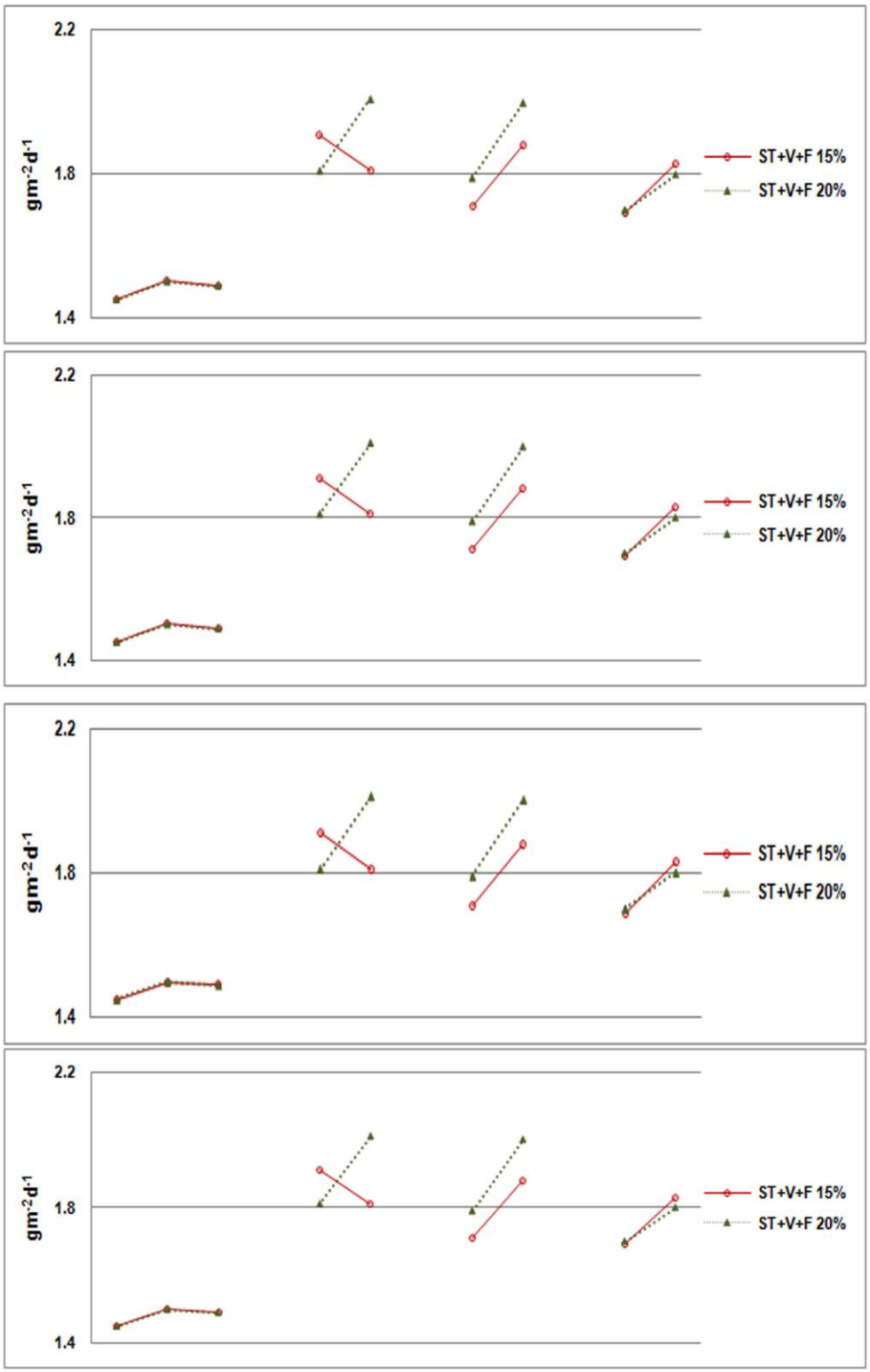


Fig 4. Effect of herbal extracts on total chlorophyll content (90 DAT)

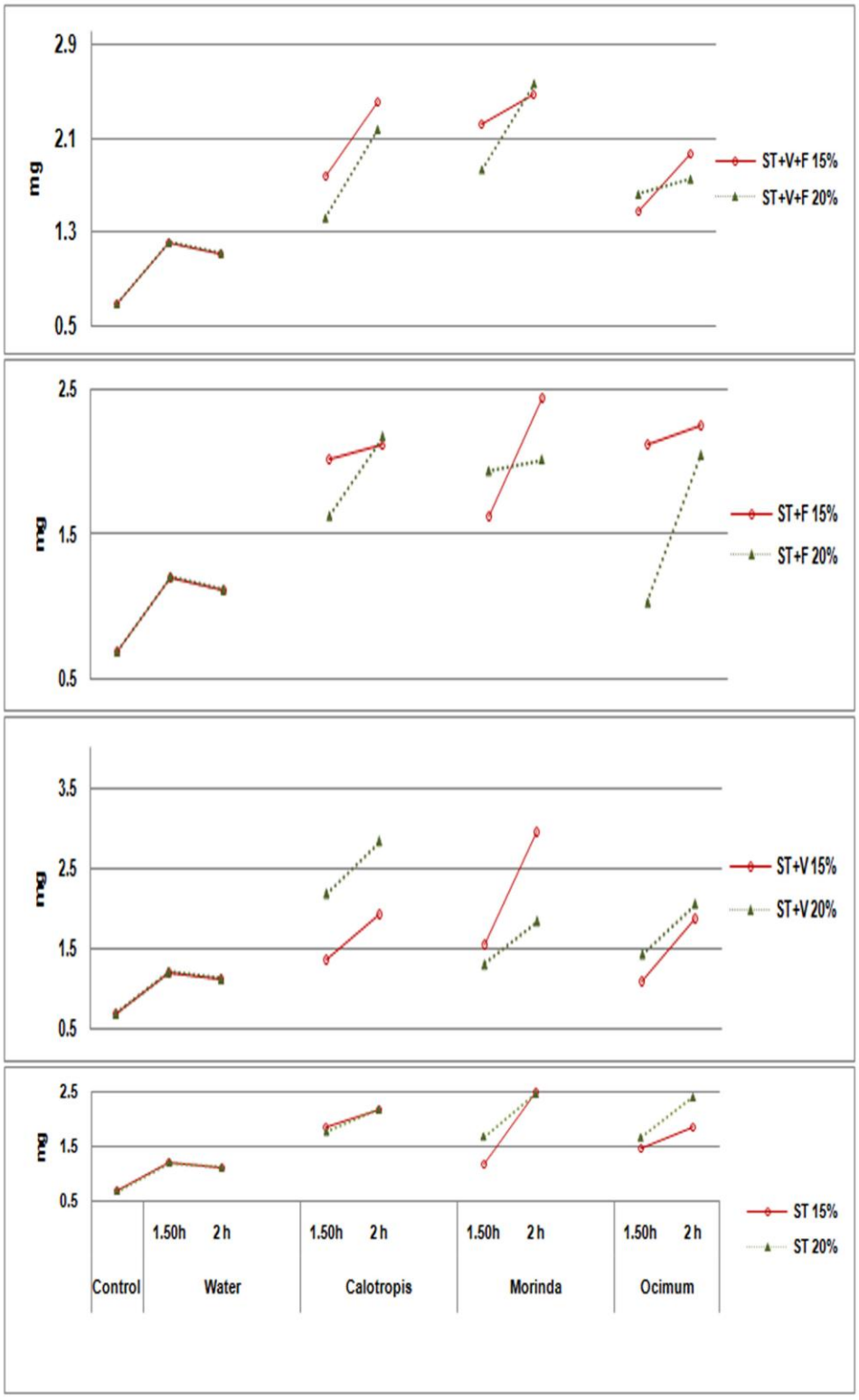


Fig.1. Standardization of concentration and soaking duration for seed treatment

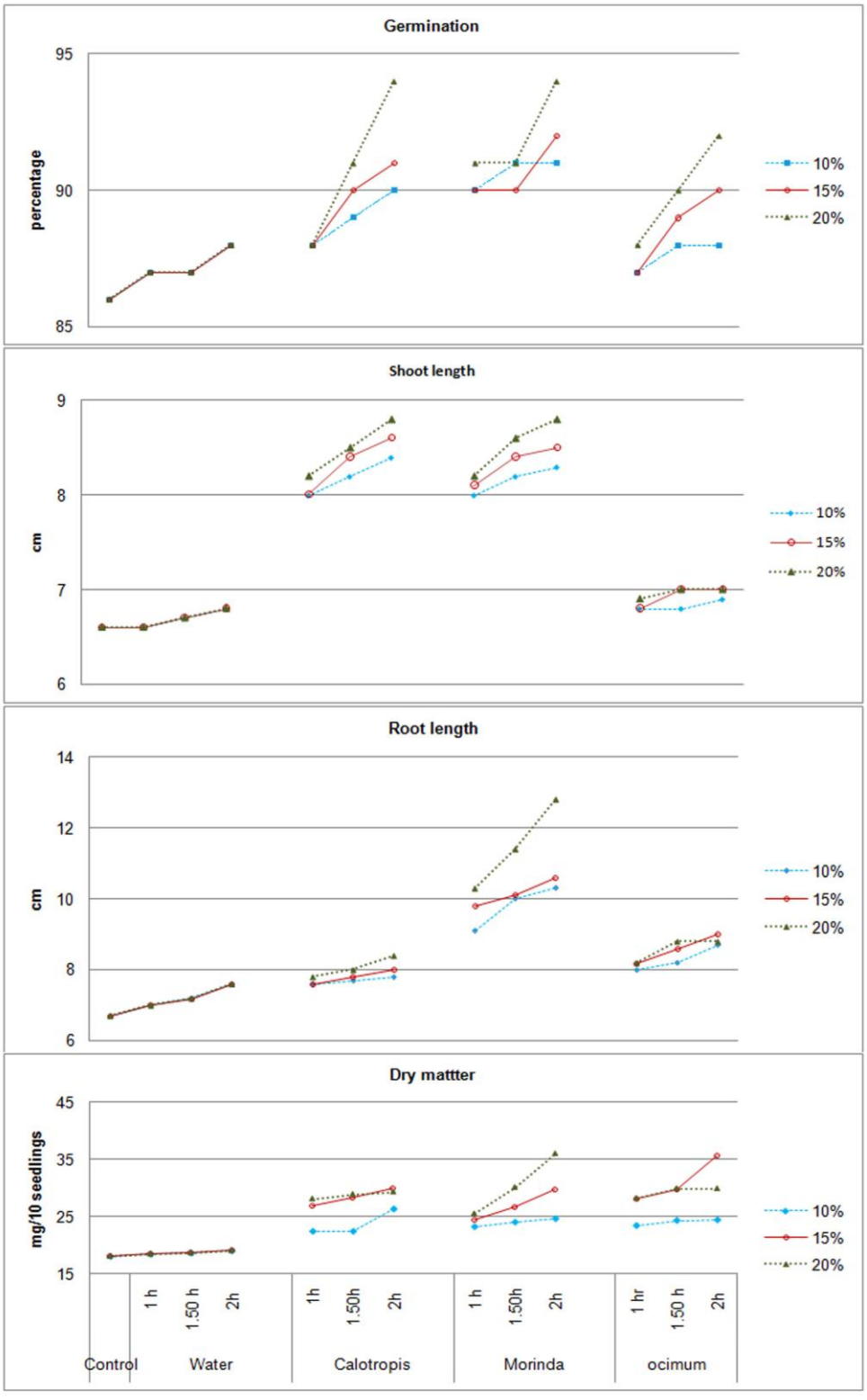
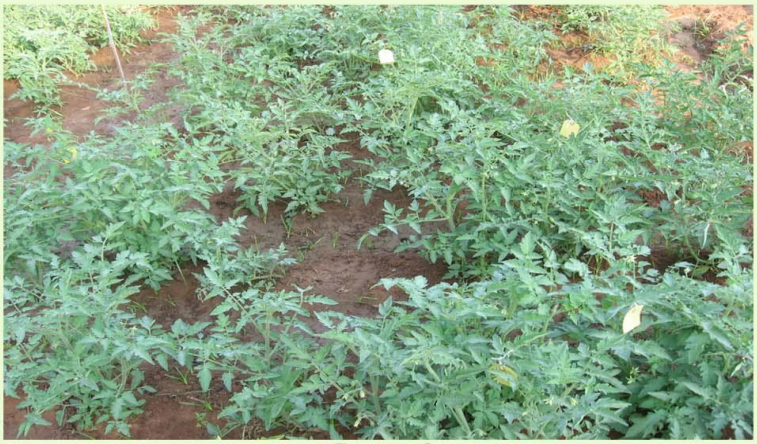


Plate 4. Effect of herbal extracts on field performance



Control

Morinda

Calotropis

Plate. 3. Over all view of the expereimental plot- Assessing efficacy of herbal extracts in tomato cv. PKM 1

Plate 2. Effect of herbal extracts on seedling characteristics

Before ageing **After ageing**

Plate 1. Evaluating the efficacy of herbal extracts

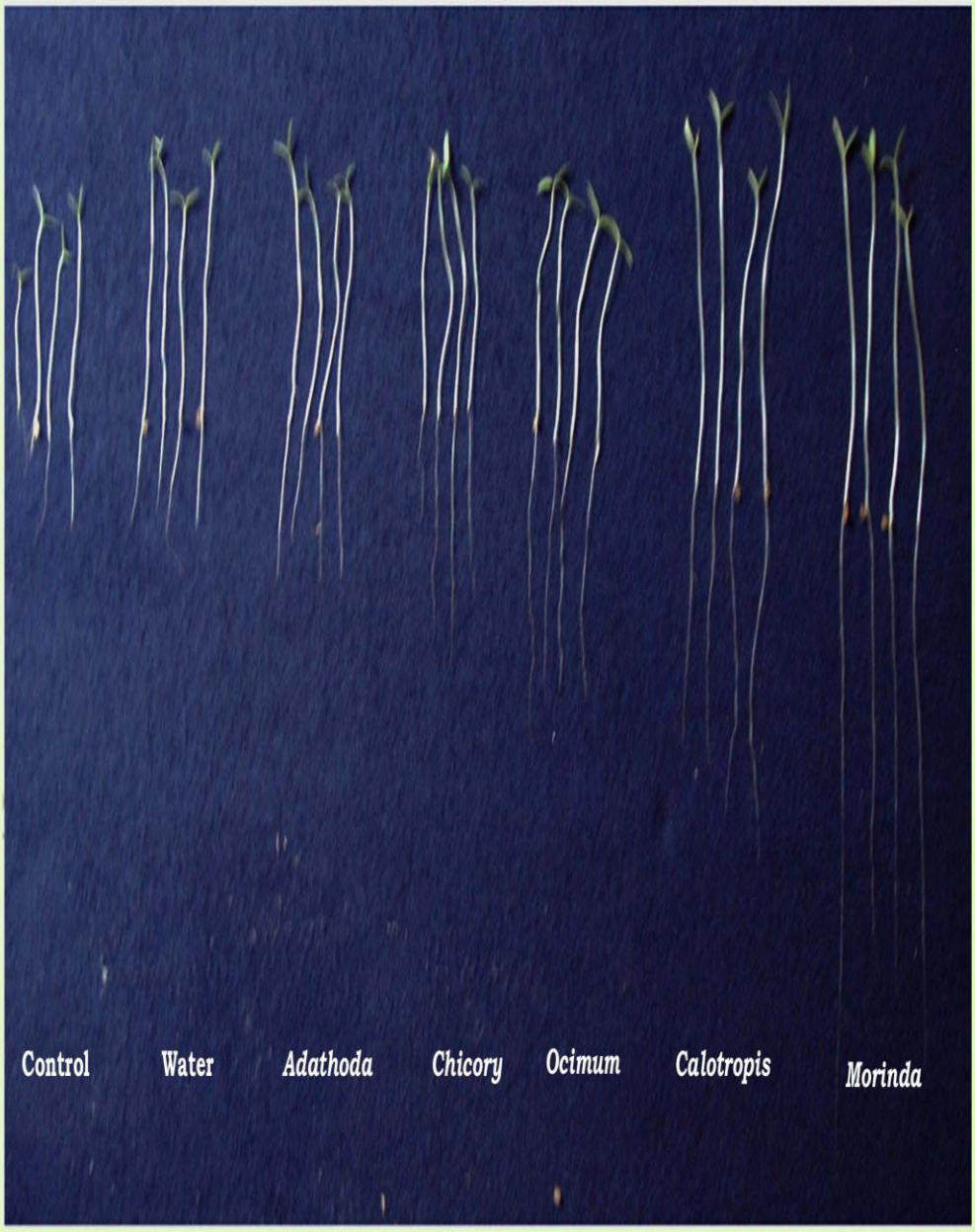


Plate 5. Effect of herbal extracts as seed treatment with different containers

CLOTH BAG

GUNNY BAG

POLYTHENE BAG

Control ***Calotropis*** ***Morinda***