MICROMETEOROLOGICAL MODIFICATION WITH MULCHES TO ENHANCE THE YIELD OF TURMERIC (*Curcuma longa* L.)

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(2019-11-205)

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"MICROMETEOROLOGICAL MODIFICATION WITH MULCHES TO ENHANCE THE YIELD OF TURMERIC (*Curcuma longa* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

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CERTIFICATE

Certified that this thesis entitled **"Micrometeorological modification with mulches to enhance the yield of turmeric (*Curcuma longa* L.)"** is a bonafide record of research work done independently by **Mr. Abin Divakaran A (2019-11-205)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Introduction

1. INTRODUCTION

Turmeric (*Curcuma longa* L.), also known as “golden spice” or “Indian saffron” is an important spice crop originated and cultivated in India. It is an annual herbaceous crop, belongs to the order Zingiberales and family Zingiberaceae.

The name turmeric has originated from the Medieval Latin name *terramerita*, which became *terre merite* of French, meaning deserved earth or meritorious earth, a name by which powdered turmeric was known in commerce. Ancient Indians had given many names for turmeric, each one denoting a particular quality eg. Ranjani denotes that which gives colour, Mangal prada-bringing luck, Krimighni-killing worms, antimicrobial etc.

Turmeric is cultivated most extensively in India, followed by Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, and Philippines. On a small scale, it is also grown in most tropical regions in Africa, America, and Pacific Ocean islands. In India turmeric has strong associations with the sociocultural life of the people. This “earthy herb of the sun” with the orange-yellow rhizome was regarded as the “herb of the sun” by the people of the Vedic period. Turmeric has at least 6000 years of documented history of its use as medicine and in many socio religious practices. India is the largest producer, exporter and consumer of turmeric in the world and India exports to over 100 countries throughout the world. UAE is the major importer of turmeric from India, followed by the U.S., Japan, U.K., Iran, Singapore, Sri Lanka, and South Africa. Indian turmeric is considered to be the best, because it has the highest curcumin content. The International Trade Centre, Geneva, has estimated an annual growth rate of 10% in the world demand for turmeric. The most important states of turmeric cultivation are Telangana, Karnataka, Andhra Pradesh, Tamil Nadu, Orissa, Kerala, Maharashtra, West Bengal and north eastern states. Telangana is the largest producer of turmeric with an area of 48000 ha with 312000 tons of production.

Turmeric powder contain 1.8 to 5.4% curcumin, 2.5 to 7.2% essential oil (tumerol), 5% fat, 3% minerals, and 69.4% carbohydrates. The yellow colour of turmeric is due to mixture of curcuminoides and curcumin. Traditionally turmeric has been used in India for treatment of a variety of human and veterinary ailments, as a natural dye, as well as preparation of delicious dishes. Studies have indicated that curcumin is nontoxic to humans even at a dose of 8000 mg d^{-1} taken continuously. The medicinal uses of turmeric and curcumin are indeed diverse, ranging from cosmetic face cream to the prevention of Alzheimer’s disease. Recent researches on turmeric are focused on its antioxidant, hepatoprotective, anti-inflammatory, anticarcinogenic, and antimicrobial properties, in addition to its use in cardiovascular and gastrointestinal disorders.

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above sea level, at a temperature range of 20-35^{0}C with an annual rainfall of 1500 mm or more, under rain fed or irrigated conditions. In India turmeric is majorly cultivated as rain fed crop, even though it can be cultivated as irrigated. The extent of influence of weather on crop growth mainly depends on its growth stages (IPCC, 2007). The impacts of climate on crop affects differently at different stages of its development. Hence, date of planting will influence the weather parameters experienced during the life cycle. Though turmeric is grown with the receipt of pre-monsoon showers, in today’s climate-changed era, farmers might benefit from knowing the best time to plant for better production techniques and yield.

Mulching is an important component in the management practices of turmeric. In the dry months, it conserves the soil moisture and regulates soil temperature for proper germination and growth of the rhizome. In addition, it improves physical properties of soil and minimizes weed competition by checking weed growth. In case of organic mulches it also enriches the fertility of soil after in situ decomposition. Organic mulches are efficient in reducing nitrate leaching, improving soil physical properties, prevention of erosion, improving nitrogen balance as well as enhancing soil biological activity. After decomposition, organic mulches return organic matter and plant nutrients to the soil and improve its physical, chemical and biological properties after decomposition, which in turn increases the crop yield. Further it prevents washing out of soil and nutrients during heavy rains. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops.

Though traditional Indian Ayurvedic and Siddha systems of medicine have recognized the medicinal value of turmeric in its crude since very ancient times we are witnessing extensive research interests worldwide in the biomedical activity of turmeric and its compounds. Curcuma is now gaining importance all over the world as a mighty cure to combat a variety of ailments, as the genus carries molecules credited with anti-inflammatory, hypocholestremic, antimicrobial, antivenomous, antiviral, antidiabetic and anticancerous properties as well as insect repellent activity. Micrometeorological aspects of turmeric have to be studied to know the crop and weather relationship. This will help the turmeric farmers to apply different micrometeorological modifications to save the crop from adverse weather situations and maintain better yield. Hence, considering these facts, the present study entitled "Micrometeorological modification with mulches to enhance the yield of turmeric (*Curcuma longa* L.)" was undertaken to evaluate the effect of different dates of panting and mulching materials on yield and yield attributes in turmeric cultivation.

Review of Literature

2. REVIEW OF LITERATURE

Turmeric (*Curcuma longa* L.) is an important spice crop. Weather parameters like maximum and minimum temperature, rainfall, rainy days etc. have important role in crop production. Hence, different dates of planting of crop help to understand effect of different environmental conditions that the weather parameters are creating. Mulching is one of the major cultural practices followed in turmeric, which helps to maintain a suitable environmental condition for better growth and development of the crop. Studying these distinct environmental conditions of the crop also helps us to understand the about incidence of pests and diseases and their impact on yield. By this we will have better knowledge about yield factors and yield limiting factors of turmeric.

The relevant literature to the present study entitled “micrometeorological modifications with mulches to enhance the yield of turmeric (*Curcuma longa* L.)” has been reviewed and presented in the chapter.

1. Significance of turmeric
2. Weather parameters
3. Effect of dates of planting on growth and yield of turmeric
4. Effect of mulches on growth and yield of turmeric
5. Effect of micrometeorological parameters on turmeric
6. Crop weather relationship of turmeric
7. Pest and disease incidence of turmeric
8. Soil nutrients

2.1. SIGNIFICANCE OF TURMERIC

Wickenberg *et al.* (2010) reported that curcumin is the active ingredient in turmeric, and it can make up 2 to 8% of the spice. Curcumin is a water-insoluble polyphenol that can be extracted using ethanol. Turmeric has long been used in Asian cuisine as a colouring agent, as well as in cheese, butter, yoghurt, and other foods. Apart from flavouring and colouring food, turmeric has a variety of uses. Curcumin has been demonstrated to have antioxidant and anti-inflammatory properties in numerous investigations. Curcumin has also been shown to alter cellular enzymes and angiogenesis in recent research. Although curcumin has been used in India and Asia for centuries, the first study on curcumin and its dose-limiting toxicity was not published until 2001, when researchers found that doses of up to 8 g per day for three months were not hazardous to people.

Pandey and Pandey (2017) reported that turmeric has been used as a safe and efficient traditional medicine for thousands of years. Turmeric is a powerful anti-inflammatory, antioxidant, and anti-aging spice. Curcumin, the miraculous chemical that gives turmeric its golden colour and many health advantages, has been extensively researched in recent decades. It possesses anti-inflammatory and antibacterial qualities as well as being a potent antioxidant. Turmeric is a potent and effective component for treating a wide range of ailments because it is rich with nutritious nutrients, vitamins, and minerals. According to studies, turmeric has a low absorption rate and a fast metabolism, resulting in low bioavailability in the body. Turmeric's anticancer qualities include suppressing cell proliferation and causing cancer cell death. Anticancer, hepatic-protective, cardioprotective, hypoglycemic, and antiarthritic effects are all found in yellow spice. Curcumin, volatile oil, and curcuminoids, among other chemicals discovered through phytochemical research of turmeric, have been proven to have powerful pharmacological activities.

2.2. WEATHER PARAMETERS

Kandiannan *et al.* (2002) reported that, turmeric can be cultivated with irrigation in locations where the average annual rainfall is between 1200 and 1500 mm. The crop can be grown up to 1200 metres above sea level. For normal development and output, it requires a temperature range of 20 to 30°C. Turmeric can grow in a variety of soil types, from light loam to heavy loam. It's best to start with a well-drained, friable, sandy loam soil that's high in organic matter. The soils which are good for turmeric is light red, brown, or ash coloured sandy loam, alkaline soils are unsuitable for growing turmeric.

Ishimine *et al*. (2004) in their study of effect of planting and date of emergence, growth and yield of turmeric reported that, turmeric Rhizome-buds did not sprout at temperatures below 10°C or above 40°C. The rate of sprouting grew from 76 to 100% as the temperature increased from 15 to 25°C, and it remained steady between 25 and 35°C, before abruptly decreasing to virtually 0 per cent at 40°C. In the temperature range of 25-35°C, around half of the rhizome-buds sprouted after two days, whereas lower temperatures slowed sprouting. The shoot length and number of turmeric plants increased significantly in all treatments until September due to the rising temperature, following which shoot growth remained consistent until October. Turmeric plants require a temperature range of 25-35°C for optimum rhizome-bud sprouting and 25-30°C for seedling growth, according to this study.

Sajitha *et al.* (2004) reported that Turmeric thrives in a warm, humid environment. A well-distributed yearly rainfall of 2500-4000 mm is required for successful rain-fed crop production.

Hossian (2010) reported that when the temperature went below 20°C, turmeric shoots became yellow.

Shylaja et al. (2011) reported that total rainfall, number of rainy days and relative humidity showed extremely significant positive connections with yield, while sunshine hours and mean sunshine hours per day showed highly significant negative associations during the months of June to September of each season.

2.3. EFFECT OF DATES OF PLANTING ON GROWTH AND YIELD OF TURMERIC

Because of the seedlings in the February, March, April, and May plantings emerged at around the same time and produced much longer shoots than those in the June planting, they showed a similar pattern in shoot elongation in both glasshouse and outdoor studies. Because the growing period was too short for the turmeric plants planted in June, shoot length and shoot number could not attain maximum values. Turmeric plants with longer stems and more shoots and leaves had a better canopy structure in the field, which prevented weed growth and received more solar energy for photosynthetic processes, resulting in an increase in crop yield (Ishimine *et al.* 2004).

Kandiannan and Chandragir (2006) in their study of varieties, dates of planting, spacing and nitrogen levels on turmeric reported during both years (2000-01 and 2001-02) of study, early turmeric plantings produced considerably taller plants, leaf area index, dry matter production, higher yield, and better quality than delayed plantings. Early planted crops accumulate more dry matter, yield, and curcumin than late planted crops because rhizome formation begins earlier and has more time to mature.

Kandiannan and Chandaragiri (2008) reported that when compared to delayed plantings, the crop that was planted on time took more TT (thermal time) to achieve different phenophases. Under normal planting, the higher TT was attributable to the longer period available to easily finish the sequential phenophases without reducing growth phases. In all three phenophases, normal planting (May 15th) yielded more TT. And on July 15th, there was a low TT accumulation. Planting turmeric in the start of the season allows for the accumulation of suitable thermal time, which may be sufficient to complete the phenophases in a timely manner, resulting in a larger output.

Kumar and gill in 2009 observed that number and weight of mother, primary and secondary rhizomes per plant increased due to each delay in harvest. This might be due to the longer growth period of plants resulted in absorbing more nutrients and moisture content from the soil in their crop period.

Manhas *et al.* (2010) reported that for all three planting materials, the planting date of April 25thand harvesting date of March 5th produced the highest yield (q ha^{-1}), gross return (Rs ha^{-1}), and net return (Rs ha^{-1}).

Sajitha *et al.* (2014) in their study to assess the phonological variations of two turmeric species found that, as the age of the plants increased, the number of green leaves per plant decreased.

Kumar *et al.* (2018) observed that varying dates of planting had a significant effect on plant height in their investigation of the impact of different pruning of *Dalbergia sissoo* and different dates of planting (20th June, 27th June and 3rd July) on turmeric. Plant height was much higher on the first date of planting (D1) than on the second date of planting (D2), and it was comparable to plant height on the third date of planting (D3). The leaf area index (19.5), number of leaves (9.7) and number of shoots per hill (4.3) in the first date of planting (D1) was considerably higher than the second date of planting (D2), number of leaves (9.5), and number of shoots per hill (4.1). Both of the dates of plantings were higher than the third date of planting (D3). The largest finger width (2.0) and fresh yield (22890.6) were produced on the first date of planting (D1), which was comparable to the second date of plantings (D2) width of fingers (1.8) and fresh yield (2590) and was superior to the (D3) third date of planting (1700).

Krishnamurthy and kandianna in 2021 revealed that at 60 days after planting (DAP), shoots received 70.4 to 71.8% biomass and rhizomes received 21.0 to 22.6%, while at 150 DAP, shoots received 22.4 to 29.0% biomass and rhizomes received 67.0 to 73.4% of total biomass. The active biomass accumulation stage in all three types is between 60 and 150 DAP, according to biomass partitioning data. The rapid rhizome development period is estimated to last between 60 and 150 days (the complete maturity of the crop occurred between 195 and 200 DAP). In all three cultivars, maximum tiller production and leaf area accumulation occurred between 60 and 120 days after planting (DAP).

2.4. EFFECT OF MULCHES ON GROWTH AND YIELD OF TURMERIC

Gill *et al.* (1999) reported that, conservation of soil moisture and lower soil temperature due to the application of straw mulch in turmeric resulted in quick emergence and taller plants with a greater number of leaves tillers and fingers. This also reduced the weed growth and showed a smothering effect on them, which resulted in the quick and better establishment of crop with favourable influence on all growth parameters on turmeric. In turn these favourable characters resulted in an increase of 46 and 44% in yield over non mulch plot.

Alam *et al.* (2003) reported that sun grass produced the most mother rhizome (2.53 per clump) while non-mulched treatment produced the least (1.70 per clump). Weight of primary finger per clump followed a similar pattern. Mulch-covered plots outperformed non-mulch-covered plots in terms of yield. However, in the current study, sun grass gave significantly higher yield (329.696 g per clump and 25.05 t ha^{-1}) than rice straw. This could be because sun grass was comparatively more compact than rice straw and was retained for longer periods, ensuring a steady supply of soil moisture during drier periods. Non mulched plots had the lowest total yield (262.80 g per clump and 19.95 t ha^{-1}), which was substantially lower than rice straw mulched plots.

Verma and Sarnaik (2006) reported that in comparison to the other treatments (no mulch, paddy straw mulch, dry grass and black polythene mulch), the treatment that employed paddy straw as mulch produced the highest average plant height (84.40 cm) and number of leaves (10.32). In the case of turmeric yield, paddy straw mulch produced the highest yield (169.33 q ha^{-1}), followed by dry grass mulch (131.33 q ha $^{-1}$).

Kandiannan *et al.* (2008) reported that raised bed gardening is necessary in many areas due to shallow soil depth. Mulching is required after planting to avoid soil splashing and seed rhizome exposure to the blazing sun, as well as to regulate soil temperature. Mulch (mainly mixed green leaves accessible in this tract) would add a lot of organic matter, improve the soil, and encourage native microorganisms in the environment, if applied at 5–10 t ha^{-1}. Mulching should be done two or three times, depending on decomposition, until the end of September, when SWM is completed. Mulching must be done in conjunction with an earthing up operation in order to establish adequate rhizomes.

Kumar *et al.* (2008) showed that turmeric plant height and stem girth were significantly higher when paddy straw mulch (1 kg m^{-2}) was applied, which was followed by grass mulch (1 kg m^{-2}) and was least in control treatment. The number of leaves did not differ considerably, but paddy straw mulch application at I kg m^{-2} increased leaf size by 27% over control. Paddy straw mulch produced the most tillers per clump, which was 57.6% more than the control treatment. The largest finger size was found in paddy straw mulched plots, followed by grass mulched plots, and the smallest in control plots. Turmeric yield was significantly greater in plots with paddy straw mulch applied at 1 kg m^{-2}, which was 56.7% higher than the control.

Nag *et al.* (2008) reported that mulches are a layer of material applied on top of the soil to maintain soil moisture, suppress weed development, minimise erosion, and prevent excessive temperature swings. Mulch changes the microclimate of the soil around the growing plants.

Sanyal and Dhar (2006) studied the effect of mulching, nitrogen and potassium levels on growth, yield and quality of turmeric. The results showed that dry leaf mulch boosted plant height and weight of mother rhizome per plant substantially. Mulching and potassium interaction as well as mulching, nitrogen, and potassium interaction, was found to have a substantial impact on the plant height and weight of the mother and finger rhizome per plant. Fresh yield, dry matter percentage, and curcumin content all increased significantly as a result of the interaction between the three parameters. Mulching plus application of nitrogen and potassium at 120 and 160 kg ha^{-1} respectively produced the highest yield with the highest curcumin content.

Singh in 2010 reported that, the application of mulch had favourable effect by modifying the soil environment by, maintaining favourable temperature, increase soil moisture, increased nutrient availability and better weed control. The higher and quicker emergence under mulch treatments might due to the reason that, as turmeric takes long time to sprout and require moist condition of the soil for better emergence, the mulching not only conserves more soil moisture but also kept the soil temperature favourable in the initial stage of growth thus enabled the early seedling emergence. The mulched plant recorded maximum height because of quick and early emergence, with favourable environment, which might be the reason for taller plant. The effect of mulch on the number of turmeric leaves per plant was significant. Turmeric + sathimoong with mulch (8.55) and turmeric + sathi maize with mulch (8.77) produced significantly more leaves per plant as compared to sole turmeric (7.17). Mulched plots produce 25 percent higher number of tillers per plant as compared to pure crops of turmeric this might be due to quick emergence, more leaf area to synthesize more food material for better growth and development of the plant. The mulch treatments produced higher number of rhizomes per plant due to overall beneficial effect of mulch. The turmeric + sathimoong + mulch and turmeric + sathi maize + mulch treatment produced significantly higher fresh weight per plant of 161.0 g and 202.5 g, respectively as compared to 112.0 g of sole treatment.

Rair *et al.* (2011) observed a decreasing trend in growth parameters like leaf area index, plant height, rhizome weight, number of leaves per plant, tiller count *etc*. in all treatments with plastic mulch compared to that of straw mulch. As a result of the study, they found that the average yield of straw mulch plot was better compared to plastic mulches in all treatment combinations of spacing and beds.

Kaur and Brar in 2016 reported that the use of straw mulch had a substantial effect on turmeric emergence count at 45–70 DAP (days after planting), but the difference was non-significant after that. At 55 DAP, the crop grown with straw mulch had a consistent plant population, whereas no-mulch plots had the same at 75 DAP. The mulched plot had considerably higher plant height, tillers per plant, mother, primary and secondary rhizomes per plant than the non-mulched plot. Crop raised with straw mulch yielded 125.2 per cent more cured rhizomes than those without. The faster emergence in mulched plots, owing to favourable moisture and temperature circumstances, appears to have resulted in higher yield realisation.

Sahoo *et al.* (2015) reported that during kharif 2007-08, the number of fingers per hill under Sal (12.13) and Sesbania leaf mulching (11.76) were considerably greater than no mulching (9.56). Sal and Sesbania leaf mulching increased fresh and dried rhizome yields much more than no mulching. Fresh (17.706 t ha^{-1}) and dry (4.817 t ha^{-1}) rhizome yields were substantially higher with Sal-leaf mulching than with Sesbania-leaf mulching (16.324 and 4.315 t ha^{-1} respectively) because of higher moisture retention capacity of Sal leaf mulch.

Sidhu *et al.* (2016) reported that the pace of plant height increase was higher up to 120 days after planting, after which the rate of plant height increase dropped. In comparison to the other treatments, the maximum plant height of 74.7 cm was recorded in treatment T10, where the inter row spacing of turmeric was 37.5 cm and mulch was applied. In the turmeric crop, the number of tillers was highest under turmeric + green gramme intercropping systems with mulching at 60 cm inter row spacing. When compared to various intercropping treatment combinations with or without mulch application, the solitary turmeric with mulching treatment (T2) yielded the highest fresh rhizome yield (210.0 q ha^{-1}), dried rhizome yield (63.1 q ha^{-1}), and processed yield (57.8 q ha^{-1}).

The application of paddy straw (T3) in ginger resulted in the highest height (43.2 cm), which was similar to all other treatments except application of coconut leaves alone (T6), cowpea mulch (T7), and plastic mulch in ginger beds. Control (T1) had a lower height measurement (29.0 cm). In ginger beds, the application of coconut leaves with green leaf mulch (T5) (966.55 cm^2) produced the most leaf area, which was similar to the applications of paddy straw (T3), coconut leaves alone (T6), and *Lantana camara* (T8). Application of paddy straw (T3) (13.3 t ha^{-1}) produced the highest yield, which was comparable to application of coir pith compost plus green leaf mulch (T4), application of coconut leaves plus green leaf mulch (T5), and application of coconut leaves alone (T6), all of which were significantly better than Farmer's practise (T2) and control (T1). The production of white coloured plastic mulch was much higher (7.52 t ha^{-1}) than the yield of farmer's practise (T2). Control (T1) had the lowest yield (3.3 t ha^{-1}), which was equivalent to beds mulched with black coloured plastic mulch (T15) (5.5 t ha^{-1}). Paddy straw (T3) application resulted in plant height (43.2 cm), leaf area (647.47 cm^2), fewer dry weight of weeds, 66.18 kg ha1, maximum weed control efficiency (72.8), and yield (13 t ha^{-1}) when compared to control (Thankamani *et al.* 2016).

Kumar *et al.* (2017) reported that turmeric plant height, number of tillers, mother, primary, and secondary rhizomes, rhizome weight, and yield increased significantly when paddy straw was used as mulch at 6.25 t ha^{-1}. Mulch use over no-mulch enhanced fresh rhizome yield by 85.0 and 34.9 percent in 2011-12 and 2012-13, respectively. Curcumin content improved slightly, but the difference between mulch and no-mulch treatments was not statistically significant.

Anburani (2018) in her study reported that transparent polythene mulch of 0.05 mm thickness recorded highest rhizome yield per plant (489.12 g), yield per plot (13.10 kg) and yield per hectare (24567.77 kg). This was followed by black polythene mulch of 439.05 g per plant, 11.38 kg per plot and 21335.65 kg ha^{-1}.

Indhulekha and Thomas (2018) in their study about mulching treatments and turmeric growth revealed that all of the mulching treatments significantly raised the plant height during the crop growth period, when compared to the no-mulch control. During the research years, the number of leaves per plant also increased in the mulched plot. The leaf area index of mulched plots was also higher, indicating that mulching boosted crop canopy coverage.

Mathew and Sreekala (2018) reported in their study on weed suppression of ginger by using organic mulches at 30, 15, and 7.5 t ha^{-1} (M1, M2, and M3, respectively) were used, as well as plastic mulch (M4). According to the study, plastic mulch can successfully inhibit weed development in ginger to a large extent when used in conjunction with mulching at 30 t ha^{-1}. The reduction in weed can effectively contribute to an improvement in yield in ginger transplants.

Manan *et al.* (2019) studied the effect of mulching and phosphatic fertilizers on turmeric using treatments, T1 - Control (No inorganic fertilizer or mulch), T2 - 100 per cent recommended dose of fertilizer (DAP 55 kg ha^{-1} and MOP 40 kg ha^{-1}) + No mulch, T3 - 25 per cent more DAP (68 kg ha^{-1}) + recommended dose of MOP (40 kg ha^{-1}) + No mulch, T4 - T2 + mulch at 6 t ha^{-1} and T5 - T3 + mulch at 6 t ha^{-1}. They reported that the maximum turmeric emergence was recorded in T5 (84.67%), which was on par with T4 (81.33%) and was superior to all the other treatments (<68% of emergence). This demonstrated the benefit of mulching by demonstrating that emergence increased with mulching regardless of the inorganic fertiliser dose. In terms of rhizome count per plot, T5 (197.0) had the highest number, which was statistically superior to all other treatments.

Chithra *et al.* (2020) reported that the plant height varied significantly from 40.10 to 58.40 cm in their experiment of mulches on black turmeric growth and yield. Plants mulched with dry grass had the maximum plant height (58.40 cm), followed by paddy straw-mulched plants (45.00 cm). The treatment T4 (dry grass as mulch) had the maximum number of leaves (16.00) while the treatment T5 (without mulch) had the lowest number of leaves (9.50 cm). Dry grass, paddy straw, coir pith, and plastic mulch raised the number of tillers per plant to more than the control. Dry grass as mulch produced the most tillers per plant (5.10), which was statistically different from the control and other treatments. Without any mulch, the lowest numbers of tillers per plant (2.30) were found. Dry grass mulch had much longer and wider leaves (35.40 cm and 9.70 cm, respectively), followed by paddy straw mulch (27.70 cm and 8.50 cm respectively). The values achieved when no mulch was used (control) were 19.60 cm and 6.40 cm, respectively. Similarly, the number of rhizomes per plant and rhizome length were considerably higher in dry grass mulch (13.34 and 7.56 cm, respectively), followed by paddy straw mulch (11.26 and 6.63 cm, respectively), whereas yield component features were lower in the absence of mulch (8.45 and 4.93 cm respectively). Treatment T4 produced the highest fresh rhizome production (22.03 t ha^{-1}) among the various treatments, increasing by 17% over control. The low yield was seen under control conditions, that is, without mulch (12.73 t ha^{-1}).

Pandey *et al.* (2020) reported that in plots applied with 10 t ha^{-1} of paddy straw mulch compared to no mulch plot showed an increased number of primary and secondary rhizomes, which was 7.9 and 8.3 primary rhizome per plant and 14.7 and 15 secondary rhizomes per plant respectively. Similarly, paddy straw mulch application resulted in increasing the weight of mother, primary and secondary rhizomes per plant.

Anshuman *et al.* (2021) reported that organic mulches and their varying thicknesses had an impact on soil organic carbon, soil pH, and soil bulk density. In comparison to the no mulched plots, all mulched plots of paddy straw at 5 t ha^{-1} and 10 t ha^{-1} had a higher concentration of soil organic carbon and a maximum decline in soil pH and bulk density. Similarly, when comparing no mulched plots, mulched plots of paddy straw at 5 and 10 t ha^{-1} showed the largest build-up of nitrogen, phosphate, and potassium availability was seen.

2.5. EFFECT OF MICROMETEOROLOGICAL PARAMETERS ON TURMERIC

Singh *et al.* (2016) reported that increased transpiration due to high light intensity favours root growth over shoot growth. Under three different tree species, a decrease in air and soil temperature (4.9-5.6% and 6.9-11.3%), a modest rise (2.3-3.4%) in humidity, and a decrease in light intensity (48.9-56.9%) altered crop development and yield performance.

Cordero et al. (2021) reported that, when it comes to the sprouting of ginger and turmeric rhizomes, temperature is crucial. The ideal temperatures to stimulate sprouting in ginger and turmeric, according to their model were 27.5°C and 30.1°C respectively. For ginger, the minimum and maximum temperatures for 5 cm sprouts were 17.1 and 35.2°C, and for turmeric, 17.2 and 32.8°C respectively. In ginger and turmeric, the sprouting times were 29 and 31 days, respectively. Temperatures below 14°C or above 40°C are likely to prevent sprouting or cause rhizome loss. The findings of this study demonstrated that temperature treatments that stimulate sprouting can be used to produce homogenous ginger and turmeric transplants. Growers may extend the production cycle of these crops by pre-sprouting seed rhizomes, as the delay in the field from seed placement to the commencement of sprouting would be removed. This is favourable, especially in colder climates where early spring planting would be beneficial. Pre-sprouting in hot climates, meanwhile, could be beneficial since it allows for improved crop establishment before high summer temperatures start to severely effect plant growth in the field.

2.6. CROP WEATHER RELATIONSHIP OF TURMERIC

Kandiannan *et al.* (2002) reported that, the first branch would generally appear one month after the seed rhizome was planted, and the weather during this time had no effect on yield. Total rainfall had a substantial (r = 0.60) relationship with yield in the second month (July). This is due to the fact that around 50–60 days after planting, new shoots stop receiving nutrients from the vegetative propagated tuber and become autotrophic, signalling the start of rapid shoot and leaf growth. Ginger, who belongs to the same family as turmeric, continues to grow rapidly until the sixth month. Water stress caused by high evaporation (6.33 mm per day) combined with low monthly total rainfall (32 mm) during this period of rapid shoot and leaf growth resulted in a negative correlation between evaporation and yield (r = 0.49) in the third month (August). Low temperatures favour the allocation of dry matter towards storage in these crops, so the mean lowest temperature of the fifth month (October), eighth month (January), and ninth month (February) showed a significant connection with yield (r = 0.45, 0.51, and 0.65, respectively). The ninth month's mean minimum relative humidity had a significant (r = 0.66) relationship with yield. The favourable effects attributed to high relative humidity could be owing to the equable temperature regime and the resulting lower heat load, which could improve respiration.

Kandiannan *et al.* (2015) observed that the average maximum daily temperature was 37.6°C throughout the first week. A temperature increase of 1°C lowers the turmeric yield by 84.83 kg ha^{-1}. When the temperature was 1°C lower than the average, the yield increased by the same amount. From the 28th week onwards, a 1°C increase in minimum daily temperature above the average had a favourable effect. If the rainfall was 1 mm less than the average from the first to the 25th week, a favourable effect of the same order might have been detected. The crop output increased by 0.77 kg ha^{-1} due to an increase of 1 mm in rainfall over the average during the 27th week. Rainfall had a positive effect in the following weeks, with a maximum advantage of 32.52 kg $ha^{-1}$when rainfall was 1 mm above average at the conclusion of the maturity period. If the weekly total rainfall had been 1 mm less than the average throughout the 27th - 43rd week, an adverse effect of the same magnitude would have occurred. A one-per cent increase in this figure reduced the yield by 8.76 kg ha^{-1}. This negative effect gradually faded till the 14th week. Following that, a unit increase in average daily maximum relative humidity had a favourable effect from the 15th week forward. The pattern persisted until harvest. The average daily sunshine was 8.7 hours day^{-1} throughout the first week. An increase of one hour has a negative impact on yield, reducing it by 85.30 kg ha^{-1}. During the following weeks, the detrimental effect declined and peaked at 270.71 kg ha^{-1} during the 28th week. After this week (Nov. 12-18), the yield gradually decreased till harvest. The daily average wind speed during the first week was 5.7 km hr^{-1}. It was discovered that increasing it above this average had a negative effect (9.2 kg ha^{-1} yield loss). This negative effect persisted throughout the growing season, increasing gradually until harvest. The average daily evaporation during the first week was 8.0 mm. An increase of 1 mm over this amount resulted in a yield loss of 11.60 kg ha^{-1}.

Bhattacharyya *et al.* (2021) reported that turmeric yield was significantly influenced by area, rainfall, maximum relative humidity, minimum relative humidity. The result indicates that area and rainfall influenced positively and on the other hand maximum relative humidity and minimum relative humidity influenced negatively. The R square value was 0.98 indicating that more than 98% of yield can be explained by these variables.

2.7. PEST AND DISEASE INCIDENCE OF TURMERIC

Kotikal and Kulkarni (2000) reported that incidence of major insect pests like shoot borer (*Conogethes punctiferalis*), rhizome fly (*Mimegralla coeruleifrons*), lacewing bug (*Stephanitis typicus*), leaf roller (*Udaspes folus*), thrips (*Panchaetothrips indicus*) and scale insects (*Aspidiotus curcumae*) were observed in all the areas of northern districts of Karnataka. The mean percentage of plants infected by the shoot borer was 7.00 + 2.33, 10.00 + 3.33 and 1.20 + 1.00 per m^2 at early vegetative phase, grand growth stage and maturity respectively. The pest incidence was highest in vegetative phase and grand growth stage.

Singh (2010) on his study of Taphrina leaf blotch on turmeric reported that, the maximum and minimum temperature showed negative correlation and relative humidity showed positive correlation. The disease was more prominent in 21-23^0C and 80% relative humidity.

Kadam *et al*. (2014) in their investigation on the relationship between weather parameters and the percent disease index of leaf blight disease on turmeric discovered that among the various weather parameters, minimum air temperature and the number of rainy days had significant correlation, whereas wind velocity had a highly significant correlation. During the lag phase of progressive disease development, i.e., from the 32nd to 35th MW (meteorological week), mean minimum (night) air temperature remained around 22^0C - 23^0C; relative humidity I, II, and mean relative humidity remained above 95%; moderate rainfall (51.1 to 471.1 mm per MW) coupled with occurrence of seven rainy days were observed. These meteorological conditions aided effective foliar infections as well as the initial pathogen (spore) population, resulting in a sluggish progression of disease (PDI 2.65 to 10.96). However, a drop in relative humidity II and mean relative humidity, as well as an increase in mean sunshine hours per day starting from 36^{th} MW (1st week of September 2012) resulted in a decrease in disease incidence.

Kumar *et al*. (2020) in their study about leaf blotch disease in turmeric reported that the plant height ranged from 84.40 to 115.64 cm (Average- 104.29 cm) in leaf blotch infected plants, while it ranged from 98.80 to 131.14 cm (Average-. 116.28 cm) in healthy plants. The leaf blotch caused an 11.99% reduction in plant height. Rhizome weight ranged from 230 to 468 g plant^{-1} (Average- 326.00 g plant^{-1}) in infected plants, while it ranged from 298 to 535 g plant^{-1} (Average- 435.75 g plant^{-1}) in healthy plants. The weight of fresh rhizome output was reduced by 25.18 percent due to leaf blotch. Losses in all growth indices were discovered as a result of the turmeric leaf blotch. Area of the leaves of infected plants ranged from 413 to 665.3 cm^2 (Av. 512.16 cm^2), while healthy plants' leaf area ranged from 598.6 to 777.3 cm^2 (694.58 cm^2). The leaf blotch resulted in a 26.27% loss in leaf area. Per plant, the number of leaves Infected plants had anywhere from 6 to 10 (Average- 7.45) leaves per plant, whereas healthy plants had anywhere from 8 to 11 (Average- 9.30) leaves per plant. The illness caused a 19.89% reduction in the number of leaves per plant. Per plant, the number of tillers infected plants had 1 to 3 tillers per plant (Average- 2.05), but healthy plants had 2 to 4 tillers per plant (Average- 2.05). Leaf blotch caused a 28.07% reduction in the number of tillers per plant. The number of fingers on diseased plants ranged from 5 to 10 (Average- 7.20), whereas healthy plants had 7 to 11 (Average- 8.70). The number of fingers per plant was reduced by 17.24 percent as a result of leaf blotch.

2.8. SOIL NUTRIENTS

Karthikeyan *et al.* (2009) in their study about potassium application in turmeric reported that, improving the potassium application rate in the form of KCl improved turmeric output and quality by increasing growth, nutrient uptake, and use. According to the findings of their research, the turmeric crop requires a lot of potassium for both productivity and quality.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Micrometeorological modification with mulches to enhance the yield of turmeric (*Curcuma longa* L.)" was carried out at the Department of Agricultural Meteorology, College of Agriculture, Vellanikkara during 2020-2021. The materials used and methods adopted for undertaking the study were described in this chapter.

3.1. DETAILS OF FIELD EXPERIMENTS

3.1.1. Field location

The field experiment was conducted in the farm of Plantation Crops and Spices, College of Agriculture, Vellanikkara, Thrissur, Kerala. Geographically the field is situated at 10° 31' N latitude and 76° 13' E longitude, at an altitude of 22 m above mean sea level.

3.1.2. Climate and weather

The experimental area was influenced by a typical warm humid tropical climatic condition and benefited by both southwest and northeast monsoons. The experimental area received a maximum amount of rainfall during the months of August and September. The mean maximum and minimum temperatures of the location recorded were 32.9 ºC and 23 ºC respectively. The average sunshine recorded for the location is 5.9 h day^{-1}. The recorded mean relative humidity was 77.7% with forenoon and afternoon relative humidity of 88.7% and 66.7% respectively. The total rainfall is 2733.9 mm. The average annual wind speed of the experimental field was 3.3 km h^{-1}. Table 3.1 shows the details of weekly weather parameters during the experimental period.

3.1.3. Season

The experiment was conducted from May (2020) to January (2021).

Table.3.1. Weekly weather parameters during the experimental period in 2020-2021

Week No	TMAX (°C)	TMIN (°C)	RH I (%)	RH II (%)	WS (km hr^{-1})	BSS (hrs)	RF (mm)	RD (days)	EVP (mm)
18	36.1	25.1	86.5	55.4	1.9	7.6	0	0	28.6
19	36.4	25	87.8	60.5	2.1	6.2	0	0	29.2
20	33.8	24.1	94.4	70.2	2	4.6	49.2	3	20.4
21	34.4	26.2	91.1	64.8	2.3	6.4	7.5	2	24.6
22	32.9	24.8	90.4	70.1	2.9	4.4	23.6	1	22.6
23	31.3	24.2	94.2	78.5	1.5	2	74.7	4	17.2
24	31.3	23.2	94.4	75.8	0.9	2	125.9	7	15.9
25	30.7	23.4	95.7	75.1	0.6	1.7	92.1	5	14.6
26	31	23.3	92.4	71.4	0.9	3.6	119	4	16.7
27	29.9	23.1	96.7	87.2	0.9	0.5	163.5	7	14.1
28	31.7	23.2	95.4	70.7	1.1	3.2	76	3	17.3
29	30.3	23.1	95.2	81.2	0.9	2.4	84.9	3	14.3
30	31.4	23.2	94.7	73.1	1.7	5.1	72.3	5	22.6
31	29.2	22.5	97.5	82.7	2.1	0.8	332	7	17.9
32	28	22.5	96.4	91.7	1.9	0.01	378.9	6	10.3
33	30.4	23.2	96	75.1	1.5	1.8	48.1	5	18.5
34	31.3	23.5	95.5	70.5	1.3	5.4	7.3	1	18.6
35	32.3	23.1	93.8	63.1	1.8	7.7	12.8	1	25.1
36	31.2	22.6	92.8	82.7	1.6	3.2	138.1	4	14.8
37	28.2	22	97.8	86	0.8	0.5	210.2	7	8.8
38	29	21.9	97.4	80.4	1.8	1.1	206.1	6	14.6
39	30.3	22.7	96.5	74.1	1.4	3.4	22	3	17.1
40	31.3	21.7	94	65.2	1.7	7.6	17.8	1	20.3
41	30.3	21.5	97	78.2	1.7	2.8	256.3	5	15.3
42	30	21.5	96.1	74	1.5	4.8	96.3	5	16.3
43	31.8	21.1	94.2	67.1	1	5.7	9.2	1	16
44	33.1	22.5	94	60.8	1.2	5.4	0	0	16.5
45	33.6	21.9	82.1	52.8	4.4	7.7	46.8	1	28
46	32.9	22.6	78.7	62	6.9	5.3	8.8	1	28.7
47	33.2	20.4	81.2	49	3.8	7.8	0	0	3.6

48	33.2	22.5	78.7	57.5	4.8	7.8	0.5	0	27.9
49	31.4	22.4	81.7	64.8	5	2.8	7.7	1	19.6
50	32.5	21	76.7	50	5.6	8.6	0	0	29.1
51	30.9	22.7	69.8	54.1	8.7	5.4	0	0	36.7
52	32.5	21.3	73.5	51.8	7.1	7.2	0	0	38.7
1	32.1	22.2	77.2	53.8	8.5	6.6	43.1	1	34.9
2	30.8	22.4	81.2	61.4	5.1	2.3	2.3	0	19.7
3	32.7	21.1	78.2	50.1	6.6	7.5	0	0	31.3
4	33.7	20.1	77	39.8	3.9	9.1	0	0	31.8
5	33.5	21.5	64.7	37	7.3	9.2	0	0	40.7

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

3.2. EXPERIMENTAL MATERIALS AND METHODS

3.2.1. Crop variety

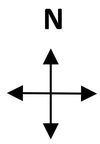
The turmeric variety, Kanthi was used for the experiment. The duration of the crop is nearly 240 to 270 days with a mean yield of 37.7 (t ha^{-1}) and a maximum dry recovery of 20.2%.

3.2.2. Design of experiment

The experiment was laid out in split plot design with four dates of planting (May 1st, May 15th, June 1st and June 15th) as the main plot treatments, four different mulches namely M1-White polythene, M2-Black polythene, M3-Paddy straw and M4-Green leaves (as per package of practice, KAU) as sub plot treatments and this was replicated four times. The details of treatment were given in Table. 3.2.

3.2.3. Layout of experiment

The field layout is shown in Fig 3.1. The treatments included were four dates of planting starting from 1st May 2020 to 15th June 2020 at 15 days interval and four different mulches (M1-White polythene, M2-Black polythene, M3-Paddy straw and



D3M2	**D2M4**	**D1M3**	**D4M3**
D3M1	**D2M3**	**D1M1**	**D4M2**
D3M4	**D2M1**	**D1M2**	**D4M4**
D3M3	**D2M2**	**D1M4**	**D4M1**

R1

D1M3	**D3M4**	**D4M4**	**D2M3**
D1M1	**D3M2**	**D4M1**	**D2M2**
D1M2	**D3M1**	**D4M2**	**D2M4**
D1M4	**D3M3**	**D4M3**	**D2M1**

R2

D3M2	**D1M4**	**D4M4**	**D2M4**
D3M3	**D1M2**	**D4M1**	**D2M2**
D3M1	**D1M3**	**D4M2**	**D2M3**
D3M4	**D1M1**	**D4M3**	**D2M1**

R3

D1M1	**D4M2**	**D2M1**	**D3M2**
D1M4	**D4M1**	**D2M4**	**D3M4**
D1M2	**D4M3**	**D2M3**	**D3M3**
D1M3	**D4M4**	**D2M2**	**D3M1**

R4

D1 – May 1st, D2 – May 15th, D3 – June 1st, D4 – June 15th

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – paddy straw mulch, M4 – Green leaf mulch

Fig. 3.1. Layout of experiment in split plot design

Plate I. Ploughing

Plate II. Bed preparation

Plate III. Planting and mulching

Plate IV. Field view after germination

Plate V. Recording observations

Plate VI. Hand weeding

Plate VII. Field view

M4- Green leaves as per package of practice of KAU). The field was divided into 64 plots of 3 x 1.2 m size each with a spacing of 40 cm between beds.

Table 3.2. Treatments used in the experiment

Main plot treatments	Subplot treatments
Planting time	Mulching material
D1 - 1st May	M1 - White polythene M2 - Black polythene M3 - Paddy straw M4 - Green leaves
D2 - 15th May	M1 - White polythene M2 - Black polythene M3 - Paddy straw M4 - Green leaves
D3 - 1st June	M1 - White polythene M2 - Black polythene M3 - Paddy straw M4- Green leaves
D4 - 15th June	M1 - White polythene M2 - Black polythene M3 - Paddy straw M4- Green leaves

3.3. CROP MANAGEMENT

3.3.1. Land preparation and planting

The land was ploughed with disc plough and then with a tractor using cultivator to achieve optimum tilth. Stubbles of the previous crop were collected and field was cleaned, then experimental layout was done. Raised beds and furrows were taken and rhizomes were planted at a spacing of 25 cm × 25 cm.

3.3.2. Manures and fertilizers

Cattle manure was incorporated into the field at the rate of 40 t ha^{-1} during land preparation. Fertilizers like urea, SSP and MOP were used to supply adequate amount of nutrients at the rate of 30:30:60 kg ha^{-1}. Full dose of SSP and half dose of MOP were applied as basal. 2/3 dose of urea was applied at 30 days after planting and 1/3 urea and remaining MOP was applied 60 days after planting.

3.3.3. Mulching

The crop was mulched immediately after planting with white polythene (20 micron thickness), black polythene mulch (20 micron thickness), paddy straw and green leaves at 15 t ha^{-1}. The mulching was repeated after 50 days with same quantity of green leaves and paddy straw mulch.

3.3.4. After cultivation

The weeding was done thrice at 60, 120 and 150 days after planting. Earthing up of the crop was done after 60 days of planting.

3.4. OBSERVATIONS

Observations on the following characteristics were done during the field experiment. The biometric and phenological observation were recorded out from five plant randomly selected from each replication of each treatment by avoiding border plants.

3.4.1. Weather data

The daily weather data on maximum temperature, minimum temperature, bright sunshine hours, rainfall and number of rainy days, relative humidity, evaporation and wind speed were collected from the agrometeorological observatory during study period. The different weather parameters used in the study were given in Table 3.3.

3.4.2. Micrometeorological observations

Soil temperature (^{0}C) at 5 and 20 cm depths and forenoon and afternoon relative humidity inside plant canopy were taken at morning 7.25 IST and afternoon 2.30 pm on daily basis. Soil moisture (%) at 5cm and 20 depths were taken on biweekly basis. The different micrometeorological parameters used in the study were given in Table 3.4.

3.4.3. Soil analysis

Soil samples were collected from the experimental field at 15 cm depths before planting. These samples were dried and powdered separately and were analysed for pH, organic carbon, electrical conductivity, available phosphorous, available potassium, available magnesium and available sulphur. Table 3.5 shows the results of chemical analysis.

3.4.4. Biometric observations

Five plants were selected randomly from each plot and tagged. The following observations were recorded from these sample plants and the mean values were worked out.

3.4.4.1. Plant height

The plant height were recorded at weekly intervals and measured in cm. It was measured using a meter scale.

3.4.4.2. Number of leaves on main tiller

The number of leaves was recorded at weekly intervals. The fully opened green leaves were considered.

3.4.4.3. Number of tillers per clump

The numbers of tillers per clump were recorded at weekly intervals.

3.4.4.4. Leaf area

The observation of the leaf area was recorded at an interval of 15 days. The leaf area was computed by multiplying leaf length, leaf width and a factor 0.72 (Tripathi *et al*. 2019).

$$\text{Leaf area (cm}^2\text{)} = (\text{leaf length} * \text{leaf width}) * 0.72$$

3.4.4.5. Dry matter accumulation

Biomass production or dry matter accumulation was estimated by taking observation of the plants at monthly interval after sowing. One healthy plant was randomly selected from the field and uprooted from each experimental sub plot. Then it was cleaned and dried in sun followed by oven drying at a temperature of 80^{0}C to a constant weight. The weight was taken and recorded in grams per plant.

Table 3.3. Weather parameters used in the experiment

Sl. No.	Weather parameter	Unit
1	Maximum temperature (TMAX)	^{0}C
2	Minimum temperature (TMIN)	^{0}C
3	Rainfall (RF)	mm
4	Rainy days (RD)	Days
5	Forenoon relative humidity (RH I) Afternoon relative humidity (RH II)	%
6	Bright sunshine hours (BSS)	hr
7	Wind speed (WS)	km hr^{-1}
8	Evaporation (Epan)	mm

Table 3.4. Micrometeorological parameters used in the experiment

Sl. No.	Micrometeorological parameters	Unit
1	Forenoon soil temperature at 5 and 20cm depth afternoon soil temperature at 5 and 20cm depth	^{0}C
2	Soil moisture at 5cm depth Soil moisture at 20cm depth	%
3	Forenoon relative humidity inside plant canopy (RH I) Afternoon relative humidity inside plant canopy (RH II)	%

Table 3.5. Chemical properties of soil analysed before the field experiment

Sl. No.	Parameters	0-15	Remarks
1	Soil pH	3.95	Extremely acidic
2	Organic carbon %	1.55	High
3	Electrical conductivity (dSm^{-1})	0.04	Normal
4	Available phosphorous (kg ha^{-1})	8.34	Low
5	Available potassium (kg ha^{-1})	162.4	Medium
6	Available magnesium (kg ha^{-1})	29.45	Low
7	Available Sulphur (kg ha^{-1})	9.78	Sufficient

3.4.5. Phenological observations

3.4.5.1. Emergence of first tiller

Number of days taken for emergence of first tiller were counted and recorded for selected plants in each dates of planting.

3.4.5.2. Emergence of last tiller

Number of days taken for emergence of last tiller were counted and recorded for selected plants in each dates of planting.

3.4.5.3. Duration of the crop

Total duration of the selected plants was noted and mean value was computed.

3.4.6. Yield and yield attributes

3.4.6.1. Length of the primary rhizome (cm)

Length of primary rhizomes was measured from sample plants of each bed and mean value was computed.

3.4.6.2. Width of primary rhizome (cm)

Width of primary rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.3. Number of mother rhizome

Number of mother rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.4. Number of primary rhizome

Number of primary rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.5. Number of secondary rhizome

Number of secondary rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.6. Weight of mother rhizome (g)

Weight of mother rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.7. Weight of primary rhizome (g)

Weight of primary rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.8. Weight of secondary rhizome (g)

Weight of secondary rhizome was measured from sample plants of each bed and mean value was computed.

3.4.6.9. Fresh yield (kg)

Fresh yield was measured from sample plants of each bed and mean value was computed.

3.4.6.10. Dry yield (kg)

Dry yield was measured from sample plants of each bed and mean value was computed.

3.4.7. Statistical analysis

Statistical analysis of the experimental data was done using the standard procedure for split plot design given by Fisher (1947). The existence of significant difference between main plot treatments (dates of planting) and sub plot treatments (mulches) and their interaction were analysed by performing ANOVA. When significant difference was found for the above, the computed critical differences were used for the pair wise comparison.

Critical difference for comparing two main plot treatments (dates of planting) was calculated as,

$$CD_1 = t_1 \times SE_1$$

Where, t_1 = t value at degrees of freedom for main plot error

SE_1 = standard error of difference between two main plot treatment means

$$SE_1 = \sqrt{\frac{2E_1}{rb}}$$

Where,

E1 = mean square for main plot error in ANOVA

r = number of replications

b = number of sub plot treatments

Critical difference for the comparison of two subplot treatments (mulches)

$$CD_2 = t_2 \times SE_2$$

Where, t_2 = t value at degrees of freedom for sub plot error

SE_2 = Standard error of difference between two sub plot treatments

$$SE_2 = \sqrt{\frac{2E_2}{ra}}$$

Where,

E_2=Error mean square value of sub plot treatments in ANOVA

r = Number of replications

a = Number of main plot treatments

Critical difference value for the comparison of two main plot treatment means at the same or different levels of sub plot treatment

$$CD_3 = t \times SE_3$$

Where, t_2 = t value at degree of freedom for subplot error

SE_3 = Standard error of difference between

$$SE_1 = \sqrt{\frac{2E_2}{r}}$$

CD_3 was used for comparing different mulches at each dates of planting

3.4.7.1. Crop weather relationship studies

To study the impact of weather parameters on biometric and phenological characters of the crop, correlation analysis was carried out. Weather variables were worked out from the daily weather data and correlated with the important crop growth and yield characters obtained from the field experiment.

Various statistical analysis were carried out using different software packages like Microsoft excel, SPSS, and R studio.

3.4.7.2. Crop yield prediction models using principal component analysis (PCA)

For fitting regression equations, principal component analysis (PCA) was done using observed weather parameters in different phenophases. The multicollinearity experienced by the weather parameters due to the relation within was minimized by this method. The principal components obtained were regressed by using SPSS software and from this better yield forecasting regression equations were derived.

Results

4. RESULTS

This chapter is presented with the results of the study entitled "micrometeorological modifications with mulches to enhance the yield of turmeric (*Curcuma longa* L.)" carried out at the Department of Agricultural Meteorology, College of Agriculture, Vellanikkara during 2020-2021.

4.1. PHENOPHASES OF TURMERIC CROP

Phenology is the study related to dates of biological events for first occurrence in their annual cycle with seasonal climatic changes. The environmental factors play a significant role on different developmental stages of turmeric.

In this study based on the morphological characters of turmeric crop, phenophases are divided into four developmental stages and are denoted by P1 to P4.

Phenophases of turmeric crop includes

1. P1 - Planting to germination
2. P2 - Germination to initiation of active tillering
3. P3 - Active tillering to bulking
4. P4 - Bulking to physiological maturity

All these phenophases comes under different growth stages such as vegetative phase, reproductive phase and ripening phase. The developmental stage from planting to germination (P1) and germination to initiation of active tillering (P2) will comes under vegetative phase. The stage active tillering to bulking (P3) comes under reproductive stage and the stage bulking to physiological maturity (P4) comes under ripening stage. The plants under different mulches showed variations in their phenophases during the four different dates of planting from May 1st to June 15th.

4.1.1. Number of days taken for germination

The number of days taken for planting to germination for different dates of planting and mulches are given in Table 4.1 and 4.2. The observations indicate that the time taken for germination was higher in May 1st date of planting and it was low in June 15th date of planting. In terms of mulches, black polythene mulch took more number of days and all other three mulches were on par and they took least number of days for germination.

4.1.2. Number of days taken for germination to initiation of active tillering

The number of days taken for germination to initiation of active tillering is given in the Table 4.1 and 4.2. The observation showed that the number of days taken for germination to initiation of active tillering was higher in May 1st date of planting and minimum in June 15th date of planting. The white polythene mulch took most days for initiation of active tillering and paddy straw mulch took lesser days for initiation of active tillering.

4.1.3. Number of days taken for active tillering to bulking

The number of days taken for initiation of active tillering to bulking is given in the table 4.1 and 4.2. The observation showed that the number of days taken for initiation of active tillering to bulking was higher in June 15th date of planting and minimum in May 1st date of planting. The white, black and paddy straw mulches took more days for bulking and they were on par with each other in case of number of days taken, the green leaves mulch took least number of days for active tillering to bulking.

4.1.4. Number of days taken for bulking to physiological maturity

Table 4.1 and 4.2 shows the days taken for bulking to physiological maturity. June 1st date of planting took more days to reach maturity compared to other date of plantings and it was least in May 1st and June 5th date of planting. In case of mulches paddy straw and green leaves were on par and took more number of days than white polythene and black polythene mulches.

Table 4.1. Influence of dates of planting on number of days taken to reach each phenophase

Dates of planting	Phenophases			
	Planting to germination (P1)	Germination to initiation of active tillering (P2)	Active tillering to bulking (P3)	Bulking to physiological maturity (P4)
D1	34.9[a]	47.00[a]	70.50[d]	62.06[c]
D2	25.93[b]	44.87[b]	80.56[c]	63.12[b]
D3	24.25[c]	37.50[c]	83.37[b]	64.68[a]
D4	18.62[d]	33.43[d]	84.87[a]	61.62[c]
CD	1.58	1.65	1.26	0.58

D1 – 1st May, D2 – 15th May, D3 – 1st June and D4 – 15th June

Table 4.2. Influence of mulches on number of days taken to reach each phenophase

Mulches	Phenophases			
	Planting to germination	Germination to initiation of active tillering	Active tillering to bulking	Bulking to physiological maturity
M1	25.18[b]	43.75[a]	80.87[a]	60.12[b]
M2	27.31[a]	40.00[b]	81.00[a]	60.12[b]
M3	25.18[b]	38.43[c]	81.12[a]	64.93[a]
M4	26.06[b]	40.62[b]	76.31[b]	66.31[a]
CD	1.02	1.01	1.14	1.68

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

4.2. OBSERVED WEATHER DURING CROP GROWTH PERIOD

The weather parameters observed during the entire crop period were recorded. The weather parameters like maximum and minimum temperature, forenoon and afternoon relative humidity (RH), rainfall (RF), bright sunshine hours (BSS), number of rainy days (RD), wind speed (WS), and evaporation (Epan) were recorded on daily basis. Weather conditions prevailed during different phenophases of the crop growth were given in the Table 4.3. to 4.6.

4.2.1. Weather conditions prevailed during planting to germination (Table 4.3)

4.2.1.1. Temperature (Maximum temperature and Minimum temperature)

In the first phenophase of white polythene mulch, highest maximum temperature of 35^0C was observed in May 1^{st} date of planting and lowest maximum temperature value of 31^0C was observed in June 1^{st} and June 15^{th} dates of planting. The highest minimum temperature value of 25^0C was observed in May 1^{st} and May 15^{th} dates of planting and lowest minimum temperature value of 23^0C was observed in June 15^{th} date of planting. In black polythene mulch the highest maximum temperature value of 34^0C was observed in May 1^{st} date of planting and lowest maximum temperature value of 31^0C was observed in June 1^{st} and June 15^{th} dates of date of planting. the highest minimum temperature value of 25^0C was observed in May 1^{st} and May 15^{th} dates of planting and lowest minimum temperature value of 23^0C was observed in June 15^{th} dates of planting. In case of paddy straw mulch highest maximum temperature value of 35^0C was observed in May 1^{st} and lowest maximum temperature value of 31^0C was observed in June 1^{st} and June 15^{th} dates of plantings. The highest minimum temperature vale of 25^0C was observed in May 1^{st} and May 15^{th} dates of plantings and the lowest minimum temperature value 23^0C was observed in June 15^{th} date of planting. In case of green leaves mulch the highest maximum temperature value of 35^0C was observed in May 1^{st} date of planting and lowest maximum temperature values of 31^0C was observed in June 1^{st} and 15^{th} dates of plantings. In case of minimum temperature, the highest recorded value 25^0C was observed in May 1^{st} date of planting and the lowest minimum temperature values of 23^0C was observed in June 1^{st} and 15^{th} dates of planting.

4.2.1.2. Relative humidity (RH1 and RH2)

The forenoon relative humidity ranged from 90 to 95% in different mulching treatments. In white polythene mulch the highest value of 94% was observed in June 1st and June 15th and lowest values of 90% was observed May 1st dates of planting. In black polythene mulch the highest value of 94% was observed in June 1st and 15th dates of planting planted crop and lowest values of 91% was observed in May 1st dates of planting. Both paddy straw and green leaf mulching treatments showed the highest and lowest values of forenoon relative humidity of 95% and 90% in June 15th and May 1st dates of plantings.

Afternoon relative humidity ranged from 63% to 77% in which, the highest and lowest values of 77% and 64% relative humidity in white polythene mulch were observed in June 1st and May 1st dates of planting. In black polythene mulch the highest and lowest values of 77% and 67% were observed during June 1st and May 1st dates of plantings. In case of paddy straw mulch the highest and lowest values of afternoon relative humidity 77% and 63% were observed in June 15th and May 1st dates of plantings. The green leaf mulch showed 77% and 64% as highest and lowest afternoon relative humidity and it was experienced in June 15th and May 1st date of plantings.

4.2.1.3. Rainfall and rainy days (RF and RD)

The white polythene mulch received highest and lowest rainfall of 264mm and 63mm in June 1st and May 1st dates of planting. In case of black polythene mulch highest and lowest rainfall of 313mm and 155mm were recorded in June 1st and May 1st planted crops. In paddy straw mulch the highest 349mm and lowest 60mm rainfall was observed in June 15th and May 1st dates of plantings. Highest and lowest rainfall of 427mm and 63mm were observed in green leaves in June 1st and May 1st planted crops.

June 1st and May 1st date of plantings observed highest and lowest number of rainy days of 15 and 5 in white polythene mulch. In case of black polythene mulch highest and lowest number of rainy days of 17 and 10 were observed during June 1st

and May 1st date of plantings. In paddy straw mulch the highest 20 and lowest 5, number of rainy days was observed during June 1st and May 1st dates of plantings. Highest and lowest rainy days of 20 and 5 were observed in green leaves during June 1st and May 1st dates of plantings.

4.2.1.4. Bright sunshine hours (BSS)

The maximum bright sunshine of 6 hrs was received during May 1st date of planting and minimum of 2 hrs was received during June 1st and 15th dates of planting in white polythene mulch. The black polythene mulch received maximum of 5 hrs in May 1st date of planting and minimum of 2 hrs in both June 1st and June 15th dates of planting. In case of paddy straw mulch the May 1st planted crop received highest maximum of 6 hrs of sunshine and June 1st and 15th received least 2hrs of sunshine. The green leaves received 6 hrs of maximum sunshine in May 1st date of planting and 2 hrs of minimum sunshine in June 1st and 15th dates of planting.

4.2.1.5. Wind speed (WS)

Wind speed showed maximum recorded value of 2 km hr^{-1} in May 1st and 15th dates of plantings and minimum of 1km hr^{-1} in June 1st and 15th dates of planting in white polythene mulch, black polythene and also straw mulch. The green leaves recorded 3 km hr^{-1} of maximum wind speed in May 15th date of planting and 1 km hr^{-1} of minimum wind speed in June 1st and June 15th dates of planting.

4.2.1.6. Pan evaporation (Epan)

Pan evaporation values showed a range in between 34mm to 137mm in all treatments. The white polythene mulch recorded highest pan evaporation of 121mm in May 1st date of planting and minimum value of 34mm in June 15th date of planting. 137mm of highest pan evaporation and 43mm of lowest evaporation was observed in black polythene mulch in May 1st and June 15th date of plantings. May 1st and June 15th date of plantings showed highest and lowest evaporation of 115mm and 47mm in paddy straw mulch. In green leaves the May 1st date of planting showed highest evaporation of 121mm and June 15th date of planting showed lowest evaporation of 50mm.

Table 4.3. Weather parameters experienced during planting to germination (P1) of turmeric under different mulches at different dates of planting

Dates of planting	**Mulches**	**Weather parameters**								
		TMAX (^{0}C)	TMIN (^{0}C)	RH1 %	RH2 %	RF (mm)	RD (Days)	BSS (hrs)	Evp (mm)	WS (Km hr^{-1})
D1- May 1st	M1	35	25	90	64	63	5	6	121	2
	M2	34	25	91	67	155	10	5	137	2
	M3	35	25	90	63	60	5	6	115	2
	M4	35	25	90	64	63	5	6	121	2
D2- May 15th	M1	33	25	93	71	155	10	4	81	2
	M2	33	25	93	72	251	14	4	90	2
	M3	33	25	93	72	143	9	5	71	2
	M4	34	25	92	70	88	7	5	67	3
D3- June 1st	M1	31	24	94	77	264	15	2	51	1
	M2	31	24	94	77	313	17	2	54	1
	M3	31	24	94	76	347	20	2	65	1
	M4	31	24	94	75	427	20	2	70	1
D4- June 15th	M1	31	23	94	74	156	11	2	34	1
	M2	31	23	94	75	292	14	2	43	1
	M3	31	23	95	77	349	16	2	47	1
	M4	31	23	95	77	379	18	2	50	1

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

4.2.2. Weather conditions prevailed during germination to initiation of active tillering (Table 4.4)

4.2.2.1. Temperature (Maximum temperature and Minimum temperature)

In the second phenophase, the white polythene mulch showed highest value of maximum temperature of 30.8^{0}C in May 1st planting and lowest value of 30.3^{0}C in June 15th planting. The highest minimum temperature value of 23.4^{0}C was observed in May 1st planting and lowest minimum temperature value of 23.1^{0}C was observed in June 15th planting. In black polythene mulch the maximum temperature value of 30.8^{0}C was observed in May 1st date of planting and lowest maximum temperature value of 30.1^{0}C was observed in June 15th date of planting and highest minimum temperature value of 23.3^{0}C was observed in May 1st and 15th dates of planting and lowest minimum temperature value of 22.9^{0}C was observed in June 15th date of planting. In case of paddy straw mulch highest and lowest maximum temperature value of 31.1^{0}C and 30.4^{0}C was observed in May 1st and June 15th dates of planting. The highest minimum temperature values of 23. 6^{0}C was observed in May 1st and lowest minimum temperature value of 23.1^{0}C was observed in June 1st and June 15th dates of plantings. In green leaves mulch the highest and lowest maximum temperature values of 30.9^{0}C and 30.3^{0}C were observed in May 1st and June 1st dates of planting. In case of minimum temperature, the highest and lowest temperature values of 23.5^{0}C and 23^{0}C were observed in May 1st and June 1st dates of planting.

4.2.2.2. Relative humidity (RH1 and RH2)

The forenoon relative humidity ranged from 94.3% to 96.1%, in which the highest and lowest values of 95.7% and 94.9% in white polythene mulch were observed in June 15th and May 1st dates of planting. In black polythene mulch the highest and lowest values of 96.1% and 94.8% were observed during June 15th and May 1st dates of plantings. In case of paddy straw mulch the highest lowest values of forenoon relative humidity 95.7% and 94.3% were observed in June 15th and May 1st

dates of plantings. The green leaf mulch showed 96% and 94.4% as highest and lowest forenoon relative humidity values in June 1st and May 1st dates of planting.

Afternoon relative humidity ranged from 76.2% to 80.1%. The white polythene mulch produced highest afternoon relative humidity of 78.9% in June 15th date of planting and lowest relative humidity value of 76.4% was observed in May 15th and June 1st date of planting. In black polythene mulch the highest and lowest values of 80.1% and 76.2% were observed in June 15th and May 15th dates of planting. In case of paddy straw mulch the highest and lowest values of 77.8% and 76.2% were observed in June 15th and May 15th dates of planting. The green leaf mulch showed 79.7% and 76.6% as highest and lowest afternoon relative humidity values in June 1st and June 15th dates of planting.

4.2.2.3. Rainfall and rainy days (RF and RD)

June 15th and May 15th dates of planting received highest and lowest rainfall of 816.6mm and 734.6mm in white polythene mulch. In case of black polythene mulch highest and lowest rainfall of 1013.5mm and 612.9mm were observed during June 15th and May 15th dates of planting. In paddy straw mulch the highest of 753.2mm and lowest of 621.4mm rainfall were observed in May 1st and June 15th dates of planting. Highest and lowest rainfall of 829.2mm and 548.3mm were received by green leaves in June 1st and June 15th dates of planting.

May 1st and 15th date of plantings received highest rainy days of 34 and June 15th received lowest number of rainy days of 26 in white polythene mulch. In case of black polythene mulch highest and lowest number of rainy days of 29 and 26 were observed during May 1st and June 15th date of plantings. In paddy straw mulch the highest 35 and lowest 21 numbers of rainy days were observed during May 1st and June 15th dates of planting. Highest and lowest rainy days of 34 and 18 were observed in green leaves during May 1st and June 15th dates of planting.

4.2.2.4. Bright sunshine hours (BSS)

The maximum bright sunshine of 2.7 hrs was received during May 15^{th} and June 1^{st} date of plantings and minimum of 2.3 hrs was received in May 1^{st} date of planting by white polythene mulch. The black polythene mulch received highest 2.7 hrs in June 1^{st} and least of and 2.3 hrs of bright sunshine hours during and May 1^{st} and June 15^{th} dates of planting. In case of paddy straw mulch the June 1^{st} and 15^{th} received 2.7 hrs of bright sunshine and May 15^{th} received 2 hrs of bright sunshine. The green leaves received 2.9 hrs of highest sunshine in June 15^{th} date of planting and 2.2 hrs of least duration of sunshine in May 1^{st} and 15^{th} dates of planting.

4.2.2.5. Wind speed (WS)

Wind speed showed maximum recorded value of 1.4 km hr^{-1} and minimum of 1 km hr^{-1} in June 15^{th} and May 15^{th} dates of planting in white polythene mulch. The black polythene mulch recorded maximum wind speed of 1.5 km hr^{-1} in June 15^{th} date planting and minimum wind speed of 0.9 km hr^{-1} in May 1^{st} date of planting. In case of paddy straw mulch maximum wind speed of 1.4 km hr^{-1} was recorded in June 15^{th} date of planting and minimum of 1 km hr^{-1} was recorded during May 15^{th} date of planting. The green leaves recorded 1.5 km hr^{-1} of maximum wind speed and 1 km hr^{-1} of minimum wind speed in June 1^{st} and May 15^{th} dates of planting.

4.2.2.6. Pan evaporation (Epan)

Pan evaporation values showed a range in between 70.3mm to 126.5mm. In this white polythene mulch recorded highest pan evaporation of 115.5mm in May 15^{th} date of planting and minimum value of evaporation of 93.1mm in June 15^{th} date of planting. 98.4mm of highest pan evaporation and 87.7mm of lowest evaporation was observed in black polythene mulch in June 1^{st} and June 15^{th} dates of planting. May 1^{st} and June 15^{th} date of plantings showed highest and lowest evaporation of 126.5mm and 77.2mm in paddy straw mulch. In green leaves the May 1^{st} date of planting showed highest evaporation of 116.1mm and June 15^{th} date of planting showed lowest evaporation of 70.3mm.

Table 4.4. Weather parameters experienced during germination to initiation of active tillering (P2) of turmeric under different mulches at different dates of planting

Dates of planting	Mulches	Weather parameters								
		TMAX (^0C)	TMIN (^0C)	RH1 %	RH2 %	RF (mm)	RD (Days)	BSS (hrs)	Evp (mm)	WS (Km hr^{-1})
D1- May 1st	M1	30.8	23.4	94.9	77.0	755.1	34.0	2.3	114.1	1.1
	M2	30.8	23.3	94.8	76.8	662.3	29.0	2.3	96.2	0.9
	M3	31.1	23.6	94.3	76.4	753.2	35.0	2.5	126.5	1.3
	M4	30.9	23.5	94.4	76.9	751.6	34.0	2.2	116.1	1.2
D2- May 15th	M1	30.8	23.2	95.0	76.4	734.6	34.0	2.7	115.5	1.0
	M2	30.7	23.3	94.9	76.2	612.9	28.0	2.5	96.4	1.0
	M3	30.7	23.3	94.7	76.2	665.4	30.0	2.0	94.8	1.0
	M4	30.8	23.4	94.9	76.7	729.7	32.0	2.2	109.1	1.0
D3- June 1st	M1	30.5	23.2	95.2	76.4	766.7	27.0	2.7	97.6	1.1
	M2	30.5	23.1	95.3	77.0	792.3	27.0	2.7	98.4	1.1
	M3	30.5	23.1	95.2	77.3	683.7	22.0	2.7	82.7	1.2
	M4	30.3	23.0	96.0	79.7	829.2	27.0	2.4	92.7	1.5
D4- June 15th	M1	30.3	23.1	95.7	78.9	816.6	26.0	2.4	93.1	1.4
	M2	30.1	22.9	96.1	80.1	1013.5	26.0	2.3	87.7	1.5
	M3	30.4	23.1	95.7	77.8	621.4	21.0	2.7	77.2	1.4
	M4	30.4	23.1	95.6	76.6	548.3	18.0	2.9	70.3	1.3

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

4.2.3. Weather conditions prevailed during initiation of active tillering to bulking (Table 4.5)

4.2.3.1. Temperature (Maximum temperature and Minimum temperature)

In the third phenophase, white polythene mulch of June 15th date of planting recorded highest maximum temperature of 30.9^{0}C and May 1st and 15th date of planting showed lowest maximum temperature value of 30.1^{0}C. The highest minimum temperature value of 22.7^{0}C was observed in May 1st planting and lowest minimum temperature value of 22.3^{0}C was observed in June 1st and 15th plantings. In black polythene mulch the highest maximum temperature value of 31^{0}C was observed in June 15th date of planting and lowest maximum temperature value of 30.2^{0}C was observed in May 1st and 15th dates of planting. In case of minimum temperature, highest minimum temperature value of 22.8^{0}C was observed in May 1st date of planting and lowest minimum temperature value of 22.3^{0}C was observed in June 1st and 15th dates of planting. In case of paddy straw mulch highest maximum temperature value of 30.9^{0}C was observed in June 15th and lowest maximum temperature value of 30.3^{0}C were observed in May 1st and 15th dates of plantings. In case of minimum temperature, the maximum minimum temperature of 22.8^{0}C was observed in May 1st planting and lowest minimum temperature value of 22.3^{0}Cwas observed in both June 1st and 15th plantings. In green leaves mulch the highest and lowest maximum temperature values 30.9^{0}C and 30.2^{0}C were observed in June 15th and May 15th dates of planting. In case of minimum temperature, the highest and lowest minimum temperature values of 22.8^{0}C and 22.3^{0}C were observed in May 1st and in June 1st and 15th plantings.

4.2.3.2. Relative humidity (RH1 and RH2)

The forenoon relative humidity ranged from 93.8% to 95.9%, in which the white polythene mulch recorded highest values of 95.9% in May 1st and 15th plantings, lowest value of 93.9% in June 15th planting. In black polythene mulch the highest humidity of 95.9% was observed in May 1st and 15th plantings, lowest value of 93.8% was observed in June 15th planting. In case of paddy straw mulch 95.8% relative humidity was observed in May 1st and 15th plantings, the lowest values of forenoon relative humidity 93.9% was observed in June 15th planting. The green leaf mulch showed 95.9% and 94.3% as highest and lowest forenoon relative humidity values in May 1st and June 15th date of plantings.

Afternoon relative humidity ranged from 71.6 to 78.1, in which white polythene mulch showed the highest humidity of 78.1% in May 1st planting and lowest values of 72.3% in June 15th planting. In black polythene mulch the highest and lowest values of 78% and 71.6% were observed in May 1st and June 15th plantings. In case of paddy straw mulch the highest and lowest values of afternoon relative humidity 77.7% and 72.6% were observed in May 1st and June 15th plantings. The green leaf mulch showed 77.8% and 72.9% as highest and lowest afternoon relative humidity values in May 1st and June 15th date of plantings.

4.2.3.3. Rainfall and rainy days (RF and RD)

May 15th and June 15th date of plantings received highest and lowest rainfall of 1566.1mm and 1378.6mm in white polythene mulch. In case of black polythene mulch highest and lowest rainfall of 1592mm and 1046.4mm were received in May 15th and June 15th plantings. In paddy straw mulch the highest 1647.7mm and lowest 1380.6mm rainfall were received in May 15th and June 15th dates of planting. Highest and lowest rainfall of 1638mm and 1239.4mm were observed in green leaves in May 15th and June 1st date of plantings.

June 1st and May 1st date of plantings received highest and lowest number of rainy days of 49 and 45 in white polythene mulch. In case of black polythene mulch highest and lowest number of rainy days of 49 and 43 were observed during May 15th and June 15th date of plantings. In paddy straw mulch the highest 52 and lowest 45 numbers of rainy days were observed during May 15th and May 1st dates of planting. Highest and lowest rainy days of 52 and 44 were observed in green leaves during May 15th and June 1st dates of planting.

4.2.3.4. Bright sunshine hours (BSS)

The maximum bright sunshine of 4.2 hrs was received during June 15th date of planting and minimum of 2.9 hrs was received during May 1st date of planting in white polythene mulch. The black polythene mulch received maximum and minimum duration of 4.3 hrs and 2.9 hrs bright sunshine hours during June 15th and May 1st date of plantings. In case of paddy straw mulch the June 15th planting received 4.1 hrs of maximum sunshine and May 1st received 3 hrs of minimum sunshine hours. The green leaves received 4.1 hrs of maximum sunshine hours in June 15th date of planting and least of 3 hrs sunshine during May 1st date of planting.

4.2.3.5. Wind speed (WS)

Wind speed showed maximum recorded value of 1.8 km ha^{-1} in June 15th planting and minimum of 1.6 km ha^{-1} in May 1st, 15th and June 1st dates of planting in white polythene and black polythene mulches. In case of paddy straw mulch maximum wind speed of 1.9 km ha^{-1}was recorded in June 15th date of planting and minimum of 1.6 km ha^{-1} recorded during May 1st, 15th and June 1st dates of planting. The green leaves recorded 1.9 km ha^{-1} of maximum wind speed and 1.5 km ha^{-1} of minimum wind speed in June 15th and June 1st date of planting.

4.2.3.6. Pan evaporation (Epan)

Pan evaporation values showed a range in between 166.3mm to 257.4mm. White polythene mulch recorded highest pan evaporation of 254.4mm in June 15th date of planting and minimum value of evaporation of 166.3mm in May 1st date of planting. 250.5mm of highest pan evaporation and 168.3mm of lowest evaporation was observed in black polythene mulch in June 15th and May 1st date of plantings. June 15th and May 1st date of plantings showed highest and lowest evaporation of 257.1mm and 178.3mm in paddy straw mulch. In green leaves the May 1st date of planting showed lowest evaporation of 176.5mm and June 15th date of planting showed highest evaporation of 257.4mm.

Table 4.5. Weather parameters experienced during initiation of active tillering to bulking (P3) of turmeric under different mulches at different dates of planting

Dates of planting	Mulches	Weather parameters								
		TMAX (^{0}C)	TMIN (^{0}C)	RH1 %	RH2 %	RF (mm)	RD (Days)	BSS (hrs)	Evp (mm)	WS (Km hr^{-1})
D1- May 1st	M1	30.1	22.7	95.9	78.1	1427.4	45.0	2.9	166.3	1.6
	M2	30.2	22.8	95.9	78.0	1427.8	45.0	2.9	168.3	1.6
	M3	30.3	22.8	95.8	77.7	1438.4	45.0	3.0	178.3	1.6
	M4	30.3	22.8	95.9	77.8	1436.8	45.0	3.0	176.5	1.6
D2- May 15th	M1	30.1	22.5	95.9	77.4	1566.1	47.0	3.1	183.2	1.6
	M2	30.2	22.5	95.9	77.4	1592.0	49.0	3.2	193.5	1.6
	M3	30.3	22.6	95.8	77.0	1647.4	52.0	3.4	214.0	1.6
	M4	30.2	22.6	95.8	77.1	1638.0	52.0	3.3	203.8	1.7
D3- June 1st	M1	30.4	22.3	95.7	75.5	1465.6	49.0	3.7	213.9	1.6
	M2	30.4	22.3	95.7	75.3	1390.1	47.0	3.8	209.4	1.6
	M3	30.4	22.3	95.7	75.5	1465.6	49.0	3.7	213.9	1.6
	M4	30.5	22.3	95.6	74.6	1239.4	44.0	3.9	199.4	1.5
D4- June 15th	M1	30.9	22.3	93.9	72.3	1378.6	46.0	4.2	254.4	1.8
	M2	31.0	22.3	93.8	71.6	1046.4	43.0	4.3	250.5	1.8
	M3	30.9	22.3	93.9	72.6	1380.6	47.0	4.1	257.1	1.9
	M4	30.9	22.3	94.3	72.9	1436.9	48.0	4.1	257.4	1.9

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

4.2.4. Weather conditions prevailed during bulking to physiological maturity (Table 4.6)

4.2.4.1. Temperature (Maximum temperature and Minimum temperature)

In the white polythene mulch, highest value of maximum temperature 32.5^0C was observed in June 1^{st} planting and lowest value of 32^0C was observed in May 1^{st} planting. The highest minimum temperature value of 21.9^0C was observed in May 15^{th}, June 1^{st} and June 15^{th} dates of planting and lowest minimum temperature value of 21.7^0C was observed in May 1^{st} planting. In black polythene mulch the highest maximum temperature value of 32.5^0C was observed in June 1^{st} date of planting and lowest maximum temperature value of 32^0C was observed in May 1^{st} date of planting. Highest minimum temperature value of 21.9^0C was observed in May 15^{th}, June 1^{st} and June 15^{th} dates of planting and lowest minimum temperature value of 21.7^0C was observed in May 1^{st} date of planting. In case of paddy straw mulch highest maximum temperature value of 32.4^0C was observed in June 1^{st} date of plantings and lowest value of 32^0C was observed in May 1^{st} and June 15^{th} dates of planting. The minimum temperature produced highest value of 22^0C in June 1^{st} and least value of 21.8^0C in May 1^{st} and June 15^{th} dates of planting. In green leaf mulching treatment the highest and lowest maximum temperature values of 32.3^0C and 32^0C were observed in June 1^{st} and May 1^{st} plantings. In case of minimum temperature, the highest and lowest minimum temperature values of 22.1^0C and 21.8^0C was observed in June 1^{st} and May 1^{st} dates of planting.

4.2.4.2. Relative humidity (RH1 and RH2)

The forenoon relative humidity ranged from 77.5% to 89.6%. The white polythene mulch showed highest and lowest values of 89.5% and 77.7% in May 1^{st} and June 15^{th} dates of planting. In black polythene mulch the highest and lowest values of 89.6% and 77.6% were observed during May 1^{st} and June 15^{th} dates of planting. In case of paddy straw mulch the highest lowest values of forenoon relative humidity 88% and 77.5% were observed in May 1^{st} and June 15^{th} dates of plantings.

The green leaf mulch showed 88.3% and 77.7% as highest and lowest forenoon relative humidity values in May 1st and June 15th date of plantings.

Afternoon relative humidity ranged from 55.2% to 63.6%. The white polythene mulch showed highest and lowest values of 63.5% and 55.7% in May 1st and June 15th dates of planting. In black polythene mulch the highest values of 63.6% in May 1st and lowest value of 55.5% was observed during June 1st and 15th dates of plantings. In case of paddy straw mulch the highest and lowest values of 63.3% and 55.2% afternoon relative humidity was observed in May 1st and June 15th dates of planting. The green leaf mulch showed 63.4% and 55.3% as highest and lowest afternoon relative humidity values in May 1st and June 15th date of plantings.

4.2.4.3. Rainfall and rainy days (RF and RD)

May 1st and June 15th date of plantings received highest and lowest rainfall of 366.4mm and 61.5mm in white polythene mulch. In case of black polythene mulch highest and lowest rainfall of 366.4mm and 61.2mm were observed during May 1st and June 15th date of plantings. In paddy straw mulch the highest 368.4mm and lowest 62.4mm rainfall was observed during May 1st and June 15th dates of plantings. Highest and lowest rainfall of 368.4mm and 61.8mm were recorded in green leaves in May 1st and June 15th dates of plantings.

May 1st date of planting received highest number of 14 rainy days in all mulching treatments. In white polythene and black polythene mulches June 1st and 15th dates of plantings received lowest number of 3 rainy days. In paddy straw and green leaf mulching treatment, least number of 3 rainy days were received in June 15th date of planting.

4.2.4.4. Bright sunshine hours (BSS)

The maximum bright sunshine of 6.5 hrs was received during June 1st date of planting and minimum of 6 hrs was received during May 1st date of planting in white polythene mulch. The black polythene mulch received maximum and minimum duration of 6.4 hrs and 5.9 hrs bright sunshine during June 1st and May 1st date of plantings. In case of paddy straw mulch the June 1st planting received more duration of 6.4 of sunshine and May 1st received least duration of 5.9 hrs of sunshine. The green leaves received 6.2 hrs of maximum sunshine in May 15th and June 15th dates of planting and least of 6 hrs during May 1st date of planting.

4.2.4.5. Wind speed (WS)

Wind speed showed maximum recorded value of 6.2 km hr^{-1} and minimum of 2.8 km hr^{-1} in June 15th and May 1st date of plantings in white polythene and black polythene mulches. In case of paddy straw mulch maximum wind speed of 6.4 km hr^{-1} was recorded in June 15th date of planting and minimum of 3.1 km hr^{-1} recorded during May 1st date of planting. The green leaves recorded 6.3 km hr^{-1} of maximum wind speed and 3.1 km hr^{-1} of minimum wind speed in June 15th and May 1st date of planting.

4.2.4.6. Pan evaporation (Epan)

Pan evaporation values showed a range in between 173.7mm to 304.1mm. In this white polythene mulch recorded highest pan evaporation value of 241.2mm in June 15th date of planting and minimum value of evaporation of 177.7mm in May 1st date of planting. 239mm of highest pan evaporation and 173.7mm of lowest evaporation was observed in black polythene mulch in June 15th and May 1st date of plantings. May 1st and June 1st date of plantings showed lowest and highest evaporation of 203.7mm and 288.9mm in paddy straw mulch. In green leaves the May 1st date of planting showed lowest evaporation of 201.2mm and June 1st date of planting showed highest evaporation of 304.1mm.

Table 4.6. Weather parameters experienced during bulking to physiological maturity (P4) of turmeric under different mulches at different dates of planting

Dates of planting	Mulches	Weather parameters								
		TMAX (^{0}C)	TMIN (^{0}C)	RH1 %	RH2 %	RF (mm)	RD (Days)	BSS (hrs)	Evp (mm)	WS (Km hr^{-1})
D1- May 1st	M1	32.0	21.7	89.5	63.5	366.4	14.0	6.0	177.7	2.8
	M2	32.0	21.7	89.6	63.6	366.4	14.0	5.9	173.7	2.8
	M3	32.0	21.8	88.0	63.3	368.4	14.0	5.9	203.7	3.1
	M4	32.0	21.8	88.3	63.4	368.4	14.0	6.0	201.2	3.1
D2- May 15th	M1	32.4	21.9	85.3	60.0	163.5	8.0	6.2	193.1	3.8
	M2	32.4	21.9	85.4	60.1	163.5	8.0	6.1	189.5	3.8
	M3	32.2	21.9	83.2	58.8	163.5	8.0	6.2	242.1	4.4
	M4	32.2	21.9	82.9	58.6	163.5	8.0	6.2	252.3	4.5
D3- June 1st	M1	32.5	21.9	79.0	55.7	63.8	3.0	6.5	229.0	5.5
	M2	32.5	21.9	79.0	55.5	63.8	3.0	6.4	231.6	5.5
	M3	32.4	22.0	78.9	56.2	107.4	4.0	6.4	288.9	5.8
	M4	32.3	22.1	78.9	56.6	108.6	4.0	6.1	304.1	5.9
D4- June 15th	M1	32.1	21.9	77.7	55.7	61.5	3.0	6.1	241.2	6.2
	M2	32.1	21.9	77.6	55.5	61.2	3.0	6.2	239.0	6.2
	M3	32.0	21.8	77.5	55.2	62.4	3.0	6.2	272.1	6.4
	M4	32.1	21.9	77.7	55.3	61.8	3.0	6.2	276.5	6.3

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

4.3. MICROMETEOROLOGICAL OBSERVATIONS

Microclimate deals with the climatic features peculiar to small areas and with the physical processes that take place in the layer of air very near to the ground. Soil ground conditions, nature of vegetation cover, aspect of slopes, state of soil surface, relief forms- all these may create special local conditions of temperature, humidity, wind and radiation in the layer of air near the ground which differ sharply from general climatic conditions.

4.3.1. Micrometeorological conditions prevailed during the crop period from planting to germination

4.3.1.1. Soil temperature (^{0}C)

Soil temperature during crop growing period of planting to germination was recorded and influence of soil temperature on crop by mulches and dates of planting was observed (Table 4.7 (a) and Table 4.8).

4.3.1.1.1. Effect of date of planting on soil temperature (^{0}C)

During the first date of planting (D1) May 1st the soil temperature at 7:30am in different treatments ranged between 28.8^{0}C to 32.9^{0}C. The temperature was higher in black polythene mulch and it was shown to be lower in green leaves. At 2:30pm the temperature ranged from 34.7^{0}C to 43.2^{0}C. The maximum afternoon temperature was shown by white polythene mulch and the minimum was shown by paddy straw mulch. The forenoon temperature recorded in second date of planting (D2) 15th May ranged from 28.2^{0}C to 31.5^{0}C in all the mulching treatments. In this date of planting maximum temperature was shown by black polythene mulch and minimum was shown by paddy straw mulch. During afternoon time the temperature ranged from 31.9^{0}C to 38.8^{0}C. The maximum temperature during afternoon hours was shown by white polythene mulch and the minimum temperature was shown by paddy straw mulch. In case of third date of planting (D3) June 15th the forenoon temperature ranged from 26.2^{0}C to 36.8^{0}C and both maximum and minimum average temperature was shown by green leaves. During afternoon the temperature ranged from 30.3^{0}C to 35.4^{0}C. In the afternoon the maximum temperature was observed in black polythene mulch and the minimum temperature was observed in paddy straw mulch. In the fourth date (D4) 15th June during morning the temperature ranged between 26.1^{0}C and 39.4^{0}C. The maximum and minimum temperatures were observed in green leaves mulch. During the afternoon hours the temperature ranged between 30.3^{0}C to 35.7^{0}C and the maximum temperature was observed in black polythene mulch and the minimum temperature was observed in green leaves.

4.3.1.1.2. Effect of mulches on soil temperature (^{0}C)

During the morning hours soil temperature ranged between 27.2^{0}C to 34^{0}C. The maximum temperature and minimum temperatures were shown by plot with green leaf mulch. In the afternoon hour's temperature ranged between 31.9^{0}C to 38.9^{0}C. During afternoon hours the maximum temperature of 38.9^{0}C was recorded in 5cm depth of white polythene mulch and minimum temperature was recorded in 20cm depth of paddy straw mulch. Top 5cm soil recorded more temperature than the soil below 20cm. The polythene mulches showed significant higher temperature than the organic mulches.

4.3.1.2. Soil moisture (%)

Soil moisture content during crop growing period of planting to germination was recorded and influence of soil moisture on crop by mulches and dates of planting were observed (Table 4.9 and Table 4.10).

4.3.1.2.1. Effect of date of planting on soil moisture (%)

In the first phenophase, soil moisture ranged from 3.4% to 13.1% in different date of plantings. The highest moisture content of 13.1 was recorded in black polythene mulch of fourth date of planting and lowest soil moisture of 3.4% was recorded in green leaves mulch of first date of planting. Significant higher soil moisture contents were recorded in late plantings.

4.3.1.2.2. Effect of mulches on soil moisture (%)

In the first phenophase soil moisture ranged from 6.6% to 10.6% in different mulching treatments. Soil moisture content was highest in 20cm depth of black polythene mulch and it was recorded lowest in 5cm depth of green leaf mulching treatment.

4.3.1.3. Relative humidity (%)

Relative humidity during crop growing period of planting to germination from plant canopy was recorded and influence of relative humidity on crop by mulches and dates of planting were observed (Table 4.11 and Table 4.12).

4.3.1.3.1. Effect of date of planting on relative humidity (%)

The relative humidity in plant canopy was higher in all date of plantings compared to air. In the morning the relative humidity inside the plant canopy ranged from 90.1% to 94.7%. The highest and lowest relative humidity percentage were recorded in June 15^{th} date of planting. During afternoon hours the relative humidity inside the plant canopy ranged from 63.6% to 77.7%. The highest measured relative humidity value was recorded in June 15^{th} date of planting and lowest recorded was in June 1^{st} date of planting.

4.3.1.3.2. Effect of mulches on relative humidity (%)

In the first phenophase forenoon relative humidity inside plant canopy ranged from 92.9% to 93.2% and it was lowest in both white polythene and green leaf mulches and recorded highest average value of 93.2% in black polythene mulch. The afternoon relative humidity of plant canopy showed that, it recorded highest average value of 72.8% in black polythene mulch and lowest average value of 71.6% in white polythene mulch.

4.3.2. Micrometeorological conditions prevailed during the crop period from germination to initiation of active tillering

4.3.2.1. Soil temperature (^{0}C)

Soil temperature during crop growing period of germination to initiation of active tillering was recorded and influence of soil temperature on crop by mulches and dates of planting was observed (Table 4.7 (b) and Table 4.8).

4.3.2.1.1. Effect of date of planting on soil temperature (^{0}C)

In the first date of planting May 1st, the forenoon soil temperature ranged from 26.2^{0}C to 33.1^{0}C. The maximum and minimum temperatures were recorded in green leaf mulch. During forenoon, the temperature ranged from 30.4^{0}C to 35.6^{0}C. The maximum temperature was shown in black polythene mulch and the minimum temperature was recorded in green leaves. During the morning the maximum temperature was recorded in 20cm depth and in afternoon the maximum temperature was recorded in 5cm depth. In the second date of planting May 15th, the forenoon temperature ranged from 26.1^{0}C to 33.3^{0}C. The maximum and minimum temperatures were recorded in green leaf mulch. In the afternoon the temperature ranged from 30.3^{0}C to 35.8^{0}C. The maximum temperature was recoded in 5cm depth of polythene mulch and minimum temperature was recorded in 20cm depth of green leaf mulch. In case of third date of planting June 1st, forenoon temperature ranged from 25.8^{0}C to 29.5^{0}C. The minimum temperature was recorded in 5cm depth of green leaf mulch and maximum temperature was recoded in 20cm depth of black polythene mulch. In the afternoon, temperature ranged from 29.7^{0}C to 35.7^{0}C in mulches. The maximum soil temperature was recorded in 5cm depth of black polythene mulch and the minimum temperature was recorded 20cm depth of green leaf. The forenoon temperature of June 15th date of planting ranged from 25.9^{0}C to 29^{0}C. The maximum temperature of 29^{0}C was recorded in 20cm depth of black polythene mulch and the minimum temperature of 25.9^{0}C was recoded in 5cm depth of green leaf. The afternoon temperature of fourth date of planting ranged from 29.9^{0}C to 35.1^{0}C in different mulching treatments. The maximum temperature was recorded in 5cm depth of black polythene mulch and the minimum temperature was recorded in 20cm depth of green leaves.

4.3.2.1.2. Effect of mulches on soil temperature (^0C)

Effect of mulches on soil temperature showed that, forenoon temperature ranged from 26^0C to 31^0C. Both highest and lowest average temperature was recorded in 20cm and 5cm depth of green leaf mulch. During the afternoon hours the temperature ranged from 30.1^0C to 34.8^0C. The highest average forenoon temperature was recorded in 5cm depth of white polythene mulch and lowest temperature was recorded in green leaf mulching.

4.3.2.2. Soil moisture (%)

Soil moisture content during crop growing period of germination to initiation of active tillering was recorded and influence of soil moisture on crop by mulches and dates of planting was observed (Table 4.9 and Table 4.10).

4.3.2.2.1. Effect of date of planting on soil moisture (%)

During the second phenophase germination to initiation of active tillering the soil moisture ranged from 8.6% to 13.9%. Green leaf mulch of June 15^{th} date of planting showed the least soil moisture content and green leaf of the June 1^{st} date of planting recorded the highest percentage of soil moisture in different mulching treatments.

4.3.2.2.2. Effect of mulches on soil moisture (%)

During the germination to initiation of active tillering period the soil moisture ranged from 11.3% to 13.4%. The highest recorded soil moisture was from 20cm depth of black polythene mulch and the lowest recorded soil moisture was from 5cm depth of paddy straw mulching treatment.

4.3.2.3. Relative humidity (%)

Relative humidity during crop growing period of germination to initiation of active tillering from plant canopy and outside was recorded and influence of relative humidity on crop by mulches and dates of planting was observed (Table 4.11 and Table 4.12).

4.3.2.3.1. Effect of date of planting on relative humidity (%)

The relative humidity in plant canopy was higher in all date of plantings compared to air. In the morning the relative humidity inside the plant canopy ranged from 92.2% to 94.8%. The highest value was recorded in both June 1st and 15th date of planting and lowest relative humidity percentage were recorded in May 15th date of planting. During afternoon hours the relative humidity inside the plant canopy ranged from 75.2% to 79%. The highest measured relative humidity value was recorded in June 15th date of planting and lowest recorded was in May 1st date of planting.

4.3.2.3.2. Effect of mulches on relative humidity (%)

In the second phenophase forenoon relative humidity inside the plant canopy ranged from 93.2% to 94.4% and it was highest in both paddy straw and green leaf mulches and recorded lowest average value of 93.2% in black polythene mulch. The afternoon relative humidity of plant canopy showed that, it recorded highest average value of 77.2% in green leaf mulch and lowest average value of 76.1% in white polythene mulch.

4.3.3. Micrometeorological conditions prevailed during the crop period from initiation of active tillering to bulking

4.3.3.1. Soil temperature (^{0}C)

Soil temperature during crop growing period of initiation of active tillering to bulking was recorded and influence of soil temperature on crop by mulches and dates of planting was observed (Table 4.7 (c) and Table 4.8).

4.3.3.1.1. Effect of date of planting on soil temperature (^{0}C)

In the first date of planting May 1st the forenoon temperature ranged from 25.6^{0}C to 29.2^{0}C in different mulching treatments. The maximum temperature of

29.2^{0}C was recorded in 20cm depth of black polythene mulch and minimum temperature of 25.6^{0}C was recorded in 5cm depth of green leaves. In the afternoon, temperature ranged from 29.5^{0}C to 35.2^{0}C, in which the highest temperature was recorded in 5cm depth of black polythene mulch and minimum temperature was recorded in 20cm depth of green leaf mulching treatment. In the second date of planting the maximum forenoon temperature of 29^{0}C was observed in black polythene mulch and minimum forenoon temperature of 25.6^{0}C was recorded in 5 cm of green leaf mulching treatment. During the afternoon hour the maximum temperature of 34.7^{0}C was recorded in 5cm of black polythene mulch and minimum temperature of 29.4^{0}C was recorded in 20 cm of green leaf mulch. In the third date of planting the maximum forenoon temperature of 29^{0}C was recorded in black polythene mulch and minimum temperature of 25.7^{0}C was recoded in 5cm depth of green leaf mulch. In case of afternoon temperature, the maximum of 34.7^{0}C was recorded in 5cm off black polythene mulch and minimum of 29.5^{0}C was recorded in green leaves. In case of fourth date of planting June 15th, the maximum forenoon temperature of 29.1^{0}C was recorded in black polythene mulch and minimum temperature of 25.9^{0}C was recorded in green leaves. During the afternoon time the maximum temperature of 35.3^{0}C was recorded in black polythene mulch and minimum temperature of 29.8^{0}C was recorded in green leaf mulching treatment.

4.3.3.1.2. Effect of mulches on soil temperature (^{0}C)

In the third phenophase of crop growth the forenoon temperature ranged from 25.6^{0}C to 29.1^{0}C in different mulching treatments. The average maximum temperature of 29.1^{0}C was recorded in 20cm depth of black polythene mulch and the average minimum temperature of 25.6 was recorded in green leaf mulching treatment. In case of afternoon temperature, the range was from 29.4^{0}C to 35^{0}C. The maximum average temperature was recorded in black polythene mulch and the lowest minimum temperature was recorded in green leaf mulching treatment.

4.3.3.2. Soil moisture (%)

Soil moisture content during crop growing period of initiation of active tillering to bulking was recorded and influence of soil moisture on crop by mulches and dates of planting was observed (Table 4.9 and Table 4.10).

4.3.3.2.1. Effect of date of planting on soil moisture (%)

During the third phenophase active tillering to bulking stage the moisture content of soil ranged from 8.7% to 13.6%. The highest moisture content was recorded in white polythene mulch of May 1st date of planting and the lowest moisture content was recorded in green leaf mulching treatment of June 15th planted crop.

4.3.3.2.2. Effect of mulches on soil moisture (%)

During the period of active tillering to bulking the soil moisture ranged from 9.7% to 12.5%. In this phenophase the maximum soil moisture was recoded in 20cm depth of black polythene mulch and minimum was recorded in 5cm depth of green leaves mulch.

4.3.3.3. Relative humidity (%)

Relative humidity during crop growing period of active tillering to bulking from plant canopy and outside was recorded and influence of relative humidity on crop by mulches and dates of planting was observed (Table 4.11 and Table 4.12).

4.3.3.3.1. Effect of date of planting on relative humidity (%)

The relative humidity in plant canopy was higher in all date of plantings compared to air. In the morning the relative humidity inside the plant canopy it ranged from 90.1% to 92.7%. The highest and lowest relative humidity percentages were recorded in May 15th and June 1st dates of planting. During afternoon hours the relative humidity inside the plant canopy ranged from 68.6% to 75.7%. The highest measured relative humidity value was recorded in June 1st date of planting and lowest recorded was in May 15th date of planting.

4.3.3.3.2. Effect of mulches on relative humidity (%)

In the third phenophase forenoon relative humidity inside plant canopy ranged from 91.2% to 92.3% and it was highest in paddy straw mulch and recorded lowest average value in black polythene mulch. The afternoon relative humidity of plant canopy showed that, it recorded highest average value of 74% in paddy straw mulch and lowest average value of 71.8% in black polythene mulch.

4.3.4. Micrometeorological conditions prevailed during the crop period from bulking to physiological maturity

4.3.4.1. Soil temperature (^{0}C)

Soil temperature during crop growing period of bulking to physiological maturity was recorded and influence of soil temperature on crop by mulches and dates of planting was observed (Table 4.7 (d) and Table 4.8).

4.3.4.1.1. Effect of date of planting on soil temperature (^{0}C)

Forenoon temperature of first date of planting May 1st ranged between 26.1^{0}C and 28.8^{0}C. The black polythene mulch showed highest temperature and the green leaves showed the lowest temperature. In case of afternoon temperature, it ranged from 30.3^{0}C to 35.2^{0}C. The black polythene mulch showed highest temperature and both green leaves and paddy straw mulch showed the lowest temperature. During the second date of planting May 15th the maximum forenoon temperature of 28.9^{0}C was recorded in 20cm depth of black polythene mulch and minimum temperature of 25.9^{0}C was shown in green leaves. In case of afternoon temperature the maximum temperature of 35.9^{0}C was recorded in black polythene mulch and minimum of 30.5^{0}C was shown in paddy straw mulch. The forenoon temperature of third date of planting June 1st ranged from 25.4^{0}C to 29.2^{0}C and the maximum was recorded in black polythene mulch and minimum was recorded in green leaves. The afternoon temperature ranged from 30.5^{0}C to 36.1^{0}C, in which the highest temperature was recorded in 5cm depth of paddy straw mulch and minimum was recorded in 20cm depth of both paddy straw and green leaves. In the last date of planting June 15th the maximum forenoon temperature of 29.4^{0}C was recorded in black polythene mulch and minimum of 24.8^{0}C was recorded in green leaves. During the afternoon hours the maximum temperature of 35.8^{0}C and the minimum of 30^{0}C were recorded in 5cm depth of black polythene mulch and 20cm depth of paddy straw mulch.

4.3.4.1.2. Effect of mulches on soil temperature (^{0}C)

In the last phenophase the average forenoon temperature ranged from 26^{0}C to 29.1^{0}C. The maximum average temperature was recorded by 20cm depth of black polythene mulch and the average minimum temperature was recorded by green leaf mulch. During the afternoon times, the temperature ranged from 30.5^{0}C to 35.8^{0}C. The average highest temperature was recorded in black polythene mulch and the average minimum temperature was recorded in paddy straw mulch.

4.3.4.2. Soil moisture (%)

Soil moisture content during crop growing period of bulking to physiological maturity was recorded at 5, 20cm depth and influence of soil moisture on crop by mulches and dates of planting was observed (Table 4.9 and Table 4.10).

4.3.4.2.1. Effect of date of planting on soil moisture (%)

During the last phenophase from bulking to physiological maturity the moisture content ranged from 4.2% to 8.4%. The highest soil moisture of 8.4% was recorded in 20cm depth of black polythene mulch in first date of planting May 1st and the lowest recorded soil moisture content was 5cm depth of paddy straw and green leaf mulch in June 15th date of planting.

4.3.4.2.2. Effect of mulches on soil moisture (%)

In the last phenophase the soil moisture ranged from 4.9% to 6.3%. The green leaf mulch produced the lowest soil moisture percentage of 4.9 and the black polythene mulch recorded highest soil moisture content of 6.3%.

4.3.4.3. Relative humidity (%)

Relative humidity during crop growing period of bulking to physiological maturity from plant canopy and outside was recorded and influence of relative humidity on crop by mulches and dates of planting was observed (Table 4.11 and Table 4.12).

4.3.4.3.1. Effect of date of planting on relative humidity (%)

The relative humidity in plant canopy was higher in all date of plantings compared to air. In the morning the relative humidity inside the plant canopy ranged from 75.3% to 87.4%. The highest and lowest relative humidity percentages were recorded in May 1st and May 15th dates of planting. During afternoon hours the relative humidity inside the plant canopy ranged from 52.6% to 63.6%. The highest measured relative humidity value was recorded in June 1st date of planting and lowest recorded was in May 15th date of planting.

4.3.4.3.2. Effect of mulches on relative humidity (%)

In the fourth phenophase, forenoon relative humidity inside plant canopy ranged from 80.6% to 81% and it was highest in both green leaf and white polythene mulch and recorded lowest average value in black polythene mulch. The afternoon relative humidity of plant canopy showed that, it recorded highest average value of 58.3% in paddy straw mulch and lowest average value of 56.8% in black polythene mulch.

Table 4.7. (a) Effect of dates of planting on soil temperature during planting to germination (P1) stage (^0C)

Date of plantings	White polythene mulch				Black polythene mulch				Paddy straw mulch				Green leaves			
	Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
D1	30.5	32. 7	43.2	38. 6	30.3	32.9	42.2	37.9	29.4	31. 3	40.7	34.7	28.8	30.5	40.2	35.6
D2	29.1	30.9	38.8	35.6	29.1	31.5	38.4	35.2	28.2	29.5	36.3	31.9	27.6	28.9	37.2	33.6
D3	27. 7	29.6	35.0	31.8	27.8	30.4	35.4	31. 7	26.8	28.6	31.4	30.3	26.2	36.8	32.3	30.5
D4	27. 7	29.7	35.0	31.3	27.7	30.1	35.7	30. 9	26.4	28.3	30. 7	30.6	26.1	39.4	31.4	30.3

Table 4.7. (b) Effect of dates of planting on soil temperature germination to initiation of active tillering (P2) stage (^0C)

Date of plantings	White polythene mulch				Black polythene mulch				Paddy straw mulch				Green leaves			
	Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
D1	27.5	29.2	34.9	31.5	27.6	29.7	35.6	31.4	26.7	28.3	31.8	30.7	26.2	33.1	32.2	30.4
D2	27.3	29.2	35.0	31.7	27.6	29.7	35.8	31.6	26.4	28.0	31.1	30.5	26.1	33.3	32.0	30.3
D3	27.2	29.0	34.9	31.5	27.4	29.5	35.7	31.5	26.3	27.8	31.6	30.3	25.8	27.6	31.8	29.7
D4	27.1	28.8	34.6	31.4	27.1	29.0	35.1	31. 3	26.3	27.7	31.7	30.0	25.9	27.6	32.3	29.9

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.7. (c) Effect of dates of planting on soil temperature during initiation of active tillering to bulking (P3) stage (^{0}C)

Date of plantings	White polythene mulch				Black polythene mulch				Paddy straw mulch				Green leaves			
	Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
D1	26.8	28.7	34.2	31.4	27.1	29.2	35.2	31.4	25.9	27.5	32.0	29.7	25.6	27.2	32.2	29.5
D2	26.8	28.5	33.8	31.3	27.0	29.0	34.7	31.2	26.0	27.5	31.9	29.8	25.6	27.2	32.0	29.4
D3	26.9	28.5	34.0	31.4	27.0	29.0	34.8	31.4	25.9	27.3	31.8	29.8	25.7	27. 3	32.1	29.5
D4	27.0	28.6	34. 4	31.6	27.2	29.1	35.3	31.7	26.1	27.5	32.1	30.0	25.9	27.5	32.3	29.8

Table 4.7. (d) Effect of dates of planting on soil temperature during bulking to physiological maturity (P4) stage (^{0}C)

Date of plantings	White polythene mulch				Black polythene mulch				Paddy straw mulch				Green leaves			
	Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon		Forenoon		Afternoon	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
D1	27.1	28.4	34.7	31.6	27.1	28.8	35.2	31.8	26.3	27.4	32. 6	30.3	26.1	27.8	32. 7	30.3
D2	27.0	28.5	35.3	31.7	27.0	28.9	35.9	32.1	26.1	27.6	33.0	30.5	25.9	27.8	33.4	30.7
D3	27.0	28.8	35.5	31.7	27.1	29.2	36.1	32.2	25.9	28.0	33.0	30.5	25.4	27.9	33.1	30.5
D4	26.4	28.8	34.9	31.2	26.7	29.4	35.8	31.8	25.2	27. 9	32. 6	30.0	24.8	27.7	33.0	30.1

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.8. Effect of mulching on soil temperature in different phenophases (^{0}C)

Mulches	P1				P2			
	Forenoon		Afternoon		Forenoon		Afternoon	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
M1	29.10	31.10	38.90	35.10	27.30	29.10	34.80	31.50
M2	29.00	31.50	38.70	34.70	27.40	29.50	35.50	31.40
M3	27.70	29.40	34.90	31.90	26.50	28.00	31.50	30.40
M4	27.20	34.00	35.30	32.50	26.00	31.00	32.10	30.10
	P3				P4			
M1	26.80	28.60	34.00	31.40	27.00	28.70	35.20	31.70
M2	27.10	29.10	35.00	31.40	27.10	29.10	35.80	32.10
M3	25.90	27.40	31.80	29.70	26.20	27.70	33.00	30.50
M4	25.60	27.20	32.00	29.40	26.00	27.80	33.30	30.60

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

Table 4.9. Effect of dates of planting on soil moisture at different phenophases (%)

Mulches	D1		D2		D3		D4		D1		D2		D3		D4	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
	P1								P2							
M1	8.1	8.3	8.1	8.3	11.5	12.3	11. 5	12.3	11.5	12.9	11.5	12.9	12.3	13.4	12.3	13.4
M2	7.7	8.4	7.7	8.4	11.7	12.6	11.6	13.1	11.6	13.1	11.6	13.1	12.3	13.5	12.6	13.9
M3	3.7	3.9	6.7	7.2	9.7	10.6	10.7	10.6	12.3	13.5	11.5	12.9	11.6	13.1	9.7	10.6
M4	3.4	3.8	6.0	6.9	8.6	9. 7	8.6	10.0	12.9	13.5	12.3	13.1	13.5	13.9	8.6	10.0
	P3								P4							
M1	12.6	13.6	11.6	12.3	11.6	11.8	9.9	10.1	6.7	6.7	6.0	6.0	4.7	4.8	4.6	4.7
M2	12. 4	13.5	11.7	13.0	11.8	12. 8	10.0	10.9	7.2	8.4	6.3	7.1	5.0	5.0	4.6	4.8
M3	10.9	11.4	10.8	11.0	11.0	11.1	9.4	9.5	6. 4	6.3	6.4	6.3	4.2	4.3	4.2	4.3
M4	10. 2	10.5	9. 9	10.1	10.3	10.1	8.7	8.9	5.6	6.0	5.6	6.0	4.2	4.9	4.2	4.9

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

Table 4.10. Soil moisture in different mulching treatments during different phenophases (%)

Mulches	P1		P2		P3		P4	
	5cm	20cm	5cm	20cm	5cm	20cm	5cm	20cm
M1	9.8	10.3	11.9	13.1	11.4	12.0	5.5	5.6
M2	9.7	10.6	12.0	13.4	11.5	12.5	5.7	6.3
M3	7.5	8.1	11.3	12.5	10.5	10.8	5.3	5.3
M4	6.6	7.6	11.8	12.6	9.7	9.9	4.9	5.5

Table 4.11. Relative humidity of different mulches in different phenophases (%)

Mulches	P1		P2		P3		P4	
	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP
M1	92.9	71.6	93.3	76.1	91.4	72.3	81.0	57.1
M2	93.2	72.8	93.2	76.4	91.2	71.8	80.6	56.8
M3	93.0	72.0	94.4	76.9	92.3	74.0	80.8	58.3
M4	92.9	71.8	94.4	77.2	91.9	73.4	81.0	57.9

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

RHMP – forenoon relative humidity inside plant canopy and RHAP – Afternoon relative humidity inside plant canopy

Table 4.12. Relative humidity of different dates of planting in different phenophases (%)

Dates of plantings	D1		D2		D3		D4		D1		D2		D3		D4	
	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP	RHMP	RHAP
Mulches	P1								P2							
M1	90.2	64.2	91.1	67.0	90.3	63.6	90.1	64.3	94.2	76.6	94.2	76.5	94.8	77.5	94.8	77.4
M2	92.8	71.2	93.1	72.1	92.9	72.1	92.5	70.0	93.6	75.7	93.6	75.8	94.7	76.3	94.6	76.6
M3	94.2	77.1	94.3	76.8	94.4	75.9	94.1	75.4	93.1	75.2	92.8	75.6	94.1	77.1	94.3	79.0
M4	94.4	74.1	94.4	75.4	94.6	76.6	94.7	77.7	92.4	76.9	92.2	77.9	94.0	76.8	93.8	75.8
	P3								P4							
M1	91.5	74.0	91.5	73.9	92.7	75.7	92.5	75.4	87.4	62.7	86.9	62.4	86.7	63.6	86.5	63.3
M2	91.8	73.5	91.7	73.3	92.7	75.0	92.3	74.8	83.7	58.8	83.3	58.9	82.0	59.2	81.8	58.5
M3	91.8	72.0	91.4	71.6	92.6	73.6	92.0	72.3	77.3	54.1	77.1	53.6	77.9	56.0	78.3	55.9
M4	90.6	69.7	90.1	68.6	91.1	71.6	90.8	71.2	75.6	52.8	75.3	52.6	76.5	54.4	77.2	54.0

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

RHMP – forenoon relative humidity inside plant canopy and RHAP – Afternoon relative humidity inside plant canopy

4.4. SOIL PARAMETERS

Soil parameters like pH, organic carbon and available nutrient status has been influenced by different mulching practices (Table 4.13).

4.4.1. Soil pH

The soil pH values after cultivation was observed to be in the range of 4.85 to 5.11. It ranged from very strongly acidic to strongly acidic. This shows that soil pH values after cultivation became less acidic than before cultivation.

4.4.2. Organic carbon (%)

The organic carbon content value ranged from 1.8% to 1.99%, and it was recorded to be high in four mulching treatments. The highest organic content was observed in plot mulched with green leaves and lowest organic content was observed in white polythene and black polythene mulched plots plot.

4.4.3. Electrical conductivity

The electrical conductivity of the soil after cultivation ranged from 0.092dSm^{-1} to 0.160dSm^{-1} in all mulching practices and there values were all in normal quantity.

4.4.4. Available nutrients (kg ha^{-1})

The available phosphorous content ranged from 111.2 kg ha^{-1} to 149.64 kg ha^{-1}. The highest recorded phosphorous content was in plot mulched with green leaves and it was lowest in black polythene mulch. The value of phosphorous content was high in all mulching practices. The available potassium content ranged from 145.04 kg ha^{-1} to 341.04 kg ha^{-1} in all mulching treatments. It was higher in paddy straw mulch and lowest in black polythene mulch. The phosphorous content ranged from medium to high, both plastic mulches showed medium range and both organic mulches recorded high after cultivation.

Table 4.13. Soil parameters after field experiment

Parameters	M1		M2		M3		M4	
	Quantity	Remarks	Quantity	Remarks	Quantity	Remarks	Quantity	Remarks
Soil pH	4.85	Very strongly acidic	5.05	Very strongly acidic	5.11	Strongly acidic	4.98	Very strongly acidic
Electrical conductivity (dSm^{-1})	0.092	Normal	0.160	Normal	0.152	Normal	1.25	Normal
Organic carbon (%)	1.80	High	1.80	High	1.86	High	1.99	High
Available phosphorous (kg ha^{-1})	148.63	High	111.20	High	141.23	High	149.64	High
Available potassium (kg ha^{-1})	146.72	Medium	145.04	Medium	341.04	High	299.71	High

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

4.5. BIOMETRIC PARAMETERS

Statistical analysis for biometric observations- plant height, number of leaves on main tiller, number of tillers per clump and leaf area were performed and analysis of covariance were presented below.

4.5.1. Plant height (cm)

Analysis of variance for plant height of turmeric was done for 30 weeks period and it was presented in Appendix III- page vi to viii.

Plant height showed significance in all the date of planting for all weeks of observation. In the first week, both third date of planting (June 1st) and fourth date of planting (June 15th) were similar and they were superior to the early dates of planting (May 1st and May 15th). The June 1st planted crop produced more plant height till the eighth week. In 9th week the third and second date of plantings were on par and higher, in 10th and 11th weeks the third date of planting produced more height. From 12th week till 16th week both second and third dates of plantings showed superior plant height and they were similar with each other. From the seventeenth week onwards second date of planting produced higher plants till harvest. The second date of planting was followed by first date of planting (May 1st) till harvest. The highest plant height was recorded in 24th week of May 15th planted crop. The fourth date of planting was inferior to all other dates of planting from 4th week onwards till harvest (Table 4.14. (a) to (c)).

The influence of mulching on plant height showed significance in all observations. Both paddy straw and green leaf mulch produced higher plants in all weeks except 16th and 19th week. During 16th and 19th week the paddy straw mulch showed significantly higher plant than other mulching treatments. Both white and black polythene mulch produced minimum plant height and they were similar with each other (Table 4.15. (a) to (c)).

The interaction between dates of planting and mulching treatments with respect to plant height found to be non-significant in all observations (Table 4.16. (a) to (j)).

Table 4.14. (a) Effect of dates of planting on plant height (cm)

Date of plantings	Weeks									
	1	2	3	4	5	6	7	8	9	10
1st May	5.82^{b}	9.35^{c}	13.93^{c}	18.55^{c}	21.58^{c}	26.92^{c}	36.11^{c}	41.65^{c}	50.62^{b}	62.71^{c}
15th May	5.50^{b}	10.80^{c}	18.57^{bc}	27.86^{b}	35.80^{b}	43.03^{b}	54.92^{b}	65.73^{b}	77.61^{a}	88.81^{b}
1st June	12.60^{a}	22.01^{a}	34.59^{a}	45.27^{a}	54.33^{a}	62.13^{a}	69.47^{a}	77.82^{a}	88.67^{a}	99.44^{a}
15th June	11.31^{a}	15.01^{b}	18.90^{b}	21.68^{c}	25.45^{c}	30.52^{c}	40.39^{c}	48.93^{c}	56.79^{b}	62.51^{c}
CD	2.58	3.38	4.69	5.21	6.19	7.85	9.03	11.28	11.34	10.40

Table 4.14. (b) Effect of dates of planting on plant height (cm)

Date of plantings	Weeks									
	11	12	13	14	15	16	17	18	19	20
1st May	72.53^{c}	85.50^{b}	100.16^{b}	117.81^{b}	130.60^{a}	134.96^{a}	140.51^{b}	144.85^{b}	146.86^{b}	148.81b
15th May	98.67^{b}	108.18^{a}	118.03^{a}	126.18^{ab}	134.46^{a}	143.47^{a}	149.47^{a}	155.13^{a}	158.46^{a}	161.16a
1st June	109.52^{a}	116.4^{a}	123.56^{a}	129.28^{a}	134.35^{a}	138.33^{a}	139.75^{b}	140.67^{b}	141.61^{b}	142.81b
15th June	68.26^{c}	75.82^{b}	83.88^{c}	90.60^{c}	97.08^{b}	102.20^{b}	106.01^{c}	109.15^{c}	112.21^{c}	114.36^{c}
CD	10.72	10.64	10.59	11.32	12.66	9.56	8.26	8.08	8.05	8.19

Table 4.14. (c) Effect of dates of planting on plant height (cm)

Date of plantings	Weeks									
	21	22	23	24	25	26	27	28	29	30
1st May	149.66^{b}	151.02^{b}	152.43^{b}	154.28^{b}	157.81^{b}	159.68^{b}	161.02^{b}	162.73^{b}	162.38^{b}	161.82^{b}
15th May	165.48^{a}	169.13^{a}	172.27^{a}	173.28^{a}	172.83^{a}	172.67^{a}	172.38^{a}	172.26^{a}	172.26^{a}	171.81^{a}
1st June	144.12^{b}	145.50^{b}	147.08^{b}	148.6^{b}	148.55^{c}	148.18^{c}	148.18^{c}	147.81^{c}	147.52^{c}	147.17^{c}
15th June	115.02^{c}	115.63^{c}	115.85^{c}	115.26^{c}	114.93^{d}	114.92^{d}	114.68^{d}	114.61^{d}	114.61^{d}	114.61^{d}
CD	8.15	7.98	8.10	8.29	7.96	7.86	7.63	7.43	7.45	7.46

Table 4.15. (a) Effect of mulches on plant height (cm)

Mulches	Weeks									
	1	2	3	4	5	6	7	8	9	10
White polythene	6.90^{b}	11.72^{b}	17.91^{b}	23.58^{b}	28.79^{b}	34.64^{b}	44.38^{b}	53.09^{b}	63.33^{b}	73.40^{b}
Black polythene	6.39^{b}	10.52^{b}	15.67^{b}	21.61^{b}	26.39^{b}	31.74^{b}	40.73^{b}	48.85^{b}	59.83^{b}	69.08^{b}
Paddy straw	11.65^{a}	18.07^{a}	26.68^{a}	34.84^{a}	42.35^{a}	49.74^{a}	60.08^{a}	68.73^{a}	77.50^{a}	88.85^{a}
Green leaf	10.29^{a}	16.86^{a}	25.72^{a}	33.33^{a}	39.63^{a}	46.48^{a}	55.71^{a}	63.46^{a}	73.03^{a}	82.14^{a}
CD	2.00	2.24	3.02	3.89	4.56	5.27	5.74	6.27	6.81	7.05

Table 4.15. (b) Effect of mulches on plant height (cm)

Mulches	Weeks									
	11	12	13	14	15	16	17	18	19	20
M1	82.42^{b}	91.15^{b}	100.48^{b}	110.19^{b}	118.79^{b}	124.06^{c}	128.07^{b}	131.95^{b}	134.40^{c}	136.26^{b}
M2	77.51^{b}	86.36^{b}	96.79^{b}	106.39^{b}	114.93^{b}	121.16^{c}	125.93^{b}	129.72^{b}	132.17^{c}	134.26^{b}
M3	98.19^{a}	107.94^{a}	118.08^{a}	127.45^{a}	135.03^{a}	140.58^{a}	143.83^{a}	146.72^{a}	149.02^{a}	150.55^{a}
M4	90.87^{a}	100.46^{a}	110.28^{a}	119.84^{a}	127.74^{a}	133.15^{b}	137.90^{a}	141.41^{a}	143.55^{b}	146.07^{a}
CD	7.55	7.93	8.29	8.20	7.81	7.35	6.62	5.85	5.40	5.07

Table 4.15. (c) Effect of mulches on plant height (cm)

Mulches	Weeks									
	21	22	23	24	25	26	27	28	29	30
M1	138.06^{b}	139.76^{b}	141.41^{b}	142.27^{b}	142.96^{b}	143.46^{b}	143.83^{b}	144.21^{b}	144.08^{b}	143.82^{b}
M2	136.1^{b}	137.76^{b}	139.32^{b}	140.38^{b}	142.08^{b}	141.41^{b}	141.51^{b}	141.97^{b}	141.72^{b}	141.53^{b}
M3	152^{a}	153.72^{a}	154.95^{a}	155.71^{a}	155.11^{a}	156.25^{a}	156.29^{a}	156.26^{a}	156.08^{a}	155.65^{a}
M4	148.13^{a}	150.05^{a}	151.96^{a}	153.06^{a}	153.97^{a}	154.33^{a}	154.63^{a}	154.97^{a}	154.88^{a}	154.41^{a}
CD	4.81	4.53	4.25	4.08	4.33	3.87	3.80	3.72	3.73	3.69

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

Table 4.16. (a) Interaction between dates of planting and mulches on plant height (cm)

Mulches	1^{st} week				2^{nd} week				3^{rd} week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	3.63	3.72	11.35	8.92	6.79	8.00	19.98	12.13	10.58	13.50	32.46	15.12
M2	4.66	3.27	9.99	7.66	7.45	7.25	16.70	10.69	11.22	11.55	26.09	13.81
M3	8.55	8.18	13.41	16.47	13.28	15.32	23.61	20.07	19.31	26.40	36.72	24.31
M4	6.46	6.83	15.66	12.21	9.88	12.65	27.77	17.16	14.61	22.85	43.09	22.35
CD	NS											

Table 4.16. (b) Interaction between dates of planting and mulches on plant height (cm)

Mulches	4^{th} week				5^{th} week				6^{th} week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	14.31	20.70	42.34	16.97	16.95	27.33	51.80	19.10	21.25	33.86	60.80	22.64
M2	15.65	17.40	37.77	15.64	18.00	22.86	45.85	18.85	23.15	28.15	52.95	22.71
M3	25.20	38.65	47.70	27.83	30.15	48.46	58.35	32.45	36.15	57.40	67.10	38.34
M4	19.05	34.70	53.28	26.30	21.25	44.50	61.35	31.40	27.15	52.70	67.70	38.40
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1^{st} May, D2 – 15^{th} May, D3 – June 1^{st} and D4 – June 15^{th}

Table 4.16. (c) Interaction between dates of planting and mulches on plant height (cm)

Mulches	7th week				8th week				9th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	29.10	46.40	69.20	32.82	34.21	57.72	78.66	41.76	44.55	69.80	89.23	49.74
M2	30.95	39.20	59.60	33.17	36.18	49.50	66.87	42.85	47.36	62.25	77.08	52.62
M3	47.75	69.90	74.95	47.72	54.13	80.95	84.24	55.62	59.10	93.30	95.35	62.25
M4	36.65	64.20	74.15	47.85	42.08	74.75	81.52	55.48	51.50	85.09	93.01	62.55
CD	NS											

Table 4.16. (d) Interaction between dates of planting and mulches on plant height (cm)

Mulches	10th week				11th week				12th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	56.70	80.87	100.62	55.40	65.73	90.70	119.43	61.60	77.21	99.54	117.90	69.95
M2	57.80	73.05	86.95	58.55	66.97	83.30	111.65	64.05	78.67	93.18	102.65	70.95
M3	74.10	104.85	108.47	68.00	85.38	113.70	119.43	74.25	100.18	122.92	126.55	82.10
M4	62.25	96.50	101.72	68.10	72.06	107.00	111.27	73.15	85.96	117.10	118.50	80.10
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.16. (e) Interaction between dates of planting and mulches on plant height (cm)

Mulches	13th week				14th week				15th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	90.20	108.28	124.90	78.55	107.65	116.83	130.65	85.65	121.77	125.45	135.75	92.20
M2	94.15	104.01	110.15	78.85	111.91	111.75	116.25	85.65	124.37	121.15	121.70	92.50
M3	115.90	133.35	133.50	89.60	133.12	141.80	138.80	96.10	144.92	149.25	143.75	102.20
M4	100.40	126.50	125.70	88.55	118.57	134.33	131.45	95.00	131.32	142.00	136.20	101.45
CD	NS											

Table 4.16. (f) Interaction between dates of planting and mulches on plant height (cm)

Mulches	16th week				17th week				18th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	124.67	134.50	139.45	97.65	129.45	140.30	140.65	101.90	134.95	146.55	141.10	105.20
M2	128.52	131.70	126.50	97.95	134.90	138.80	128.35	101.70	139.25	144.85	129.60	105.20
M3	151.10	156.90	147.15	107.20	155.10	162.15	147.35	110.75	158.45	167.30	148.00	113.15
M4	135.57	150.80	140.25	106.00	142.60	156.65	142.65	109.70	146.75	161.85	144.00	113.05
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.16. (g) Interaction between dates of planting and mulches on plant height (cm)

Mulches	19th week				20th week				21st week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	138.35	149.75	141.35	108.15	140.45	153.00	141.65	109.95	141.60	158.30	141.95	110.40
M2	141.10	149.00	130.65	107.95	143.20	152.75	131.75	109.35	143.90	157.50	133.30	109.70
M3	159.60	171.10	148.80	116.60	160.80	172.40	1490.85	119.15	161.55	175.45	150.80	120.20
M4	148.40	164.00	145.65	116.15	150.80	166.50	148.00	119.00	151.60	17070	150.45	119.80
CD	NS											

Table 4.16. (h) Interaction between dates of planting and mulches on plant height (cm)

Mulches	22nd week				23rd week				24th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	143.10	162.85	142.010	111.00	144.80	167.15	142.40	111.30	147.00	168.20	142.95	110.95
M2	145.65	161.25	134.30	109.85	147.35	164.75	135.35	109.85	149.30	166.45	136.55	109.25
M3	163.00	178.45	152.50	120.95	163.85	180.45	154.50	121.00	165.50	180.50	156.60	120.25
M4	152.35	174.00	153.10	120.75	153.75	176.75	156.10	121.25	155.35	178.00	158.30	120.60
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.16. (i) Interaction between dates of planting and mulches on plant height (cm)

Mulches	25th week				26th week				27th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	150.30	167.95	142.80	110.80	152.50	167.85	142.70	110.80	154.25	167.70	142.70	110.70
M2	152.95	166.10	136.55	112.75	154.85	166.00	136.00	108.80	155.85	165.65	136.00	108.55
M3	168.30	179.70	156.60	115.85	169.45	179.50	156.32	119.75	170.00	179.30	156.32	119.55
M4	159.70	177.60	158.25	120.35	161.95	177.35	157.70	120.35	164.00	176.90	157.70	119.95
CD	NS											

Table 4.16. (j) Interaction between dates of planting and mulches on plant height (cm)

Mulches	28th week				29th week				30th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	156.25	167.65	142.35	110.60	155.95	167.65	142.15	110.60	155.50	167.40	141.80	110.60
M2	158.10	165.50	135.75	108.55	157.35	165.50	135.50	108.55	156.95	165.40	135.25	108.55
M3	170.50	179.20	155.89	119.45	170.15	179.20	155.55	119.45	169.45	178.45	155.25	119.45
M4	166.10	176.70	157.25	119.85	166.10	176.70	156.90	119.85	165.40	176.00	156.40	119.85
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.5.2. Number of leaves on main tiller

Analysis of variance for number of leaves of turmeric was done for 30 weeks period and it was presented in Appendix III- page ix to x.

The influence of date of planting on number of leaves on main tiller showed significance in fortnightly intervals. Both June 1st and June 15th dates of planting were similar with each other and produced higher number of leaves till 7th week. During 9th week 2nd, 3rd and 4th dates of plantings were on par and recorded more number of leaves. In 11th week, third date of planting recorded more number of leaves, it was on par with second date of planting May 15th and fourth date of plantings June 15th. During 13th and 15th week, May 15th planted crop and June 1st planted crop produced higher number of leaves and they were similar with each other. In 17th, 19th and 21st weeks May 1st, May 15th and June 1st dates of plantings produced more number of leaves and they were on par with each other. From 23rd week till harvest both first and second dates of plantings showed higher number of leaves (Table 4.17).

In case of mulching treatments significant difference was shown until 5th week, from there till harvest mulching practices didn't show any significance in number of leaves. During 1st, 3rd and 5th week after planting both paddy straw mulch and green leaf mulches showed significant higher number of leaves than white and black polythene mulching treatments (Table 4.18).

The interaction between dates of planting and mulching treatments on number of leaves on main tiller found to be non-significant in all observations (Table 4.19. (a) to (d)).

Table 4.17. Influence of dates of planting on number of leaves on main tiller

Date of planting	Number of leaves														
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
D1	0.66^{b}	1.18^{c}	3.33^{b}	3.72^{c}	4.62^{b}	5.75^{b}	6.28^{b}	6.76^{b}	7.51^{a}	7.76^{a}	7.86^{a}	8.12^{a}	8.12^{a}	8.12^{a}	8.12^{a}
D2	0.46^{b}	1.61^{b}	3.11^{b}	4.28^{b}	6.40^{a}	6.40^{ab}	7.02^{a}	7.22^{a}	7.50^{a}	7.86^{a}	7.86^{a}	8.02^{a}	8.02^{a}	8.02^{a}	8.02^{a}
D3	1.13^{a}	3.07^{a}	3.83^{a}	4.95^{a}	6.43^{a}	7.03^{a}	7.23^{a}	7.33^{a}	7.38^{a}	7.60^{a}	7.60^{a}	7.62^{b}	7.62^{b}	7.62^{b}	7.62^{b}
D4	1.22^{a}	1.93^{b}	1.93^{c}	5.05^{a}	6.16^{a}	6.32^{ab}	6.37^{b}	6.37^{c}	6.37^{b}	6.42^{b}	6.45^{b}	6.47^{c}	6.47^{c}	6.47^{c}	6.47^{c}
CD	0.21	0.32	0.30	0.35	0.75	0.76	0.48	0.37	0.35	0.36	0.38	0.34	0.31	0.33	0.31

Table 4.18. Influence of mulching on number of leaves on main tiller

Mulches	Number of leaves														
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
M1	0.62^{b}	1.85^{bc}	2.96^{bc}	4.47	5.83	6.36	6.76	6.82	7.15	7.37	7.43	7.48	7.48	7.48	7.48
M2	0.60^{b}	1.75^{c}	2.88^{c}	4.31	5.73	6.25	6.58	6.83	7.06	7.30	7.33	7.51	7.51	7.51	7.51
M3	1.18^{a}	2.11^{a}	3.15^{ab}	4.56	5.91	6.33	6.70	6.86	7.26	7.52	7.52	7.63	7.63	7.63	7.63
M4	1.07^{a}	2.10^{ab}	3.22^{a}	4.66	6.13	6.56	6.87	7.17	7.30	7.45	7.47	7.61	7.61	7.61	7.61
CD	0.23	0.25	0.24	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.19. (a) Interaction between dates of planting and mulches on number of leaves

Mulches	1				3				5				7			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	0.25	0.30	1.00	0.95	0.95	1.40	3.25	1.80	3.05	3.25	3.75	1.80	3.50	4.45	4.90	5.05
M2	0.65	0.20	0.65	0.90	1.00	1.30	2.95	1.75	3.10	2.70	4.00	1.75	3.55	3.95	5.00	4.75
M3	1.05	0.75	1.35	1.60	1.45	1.95	2.95	2.10	3.75	3.15	3.60	2.10	4.15	4.15	4.85	5.10
M4	0.70	0.60	1.55	1.45	1.35	1.80	3.15	2.10	3.45	3.35	4.00	2.10	3.70	4.60	5.05	5.30
CD	NS															

Table 4.19. (b) Interaction between dates of planting and mulches on number of leaves

Mulches	9				11				13				15			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	4.35	6.50	6.50	6.00	5.60	6.50	7.15	6.2	6.25	7.30	7.30	6.20	6.55	7.2	7.35	6.20
M2	4.65	5.95	6.20	6.15	5.80	5.95	6.95	6.3	6.20	6.70	7.07	6.35	6.65	7.2	7.15	6.35
M3	4.90	6.30	6.25	6.20	5.90	6.30	6.75	6.4	6.40	6.90	7.00	6.50	6.85	6.9	7.20	6.50
M4	4.60	6.85	6.80	6.30	5.70	6.85	7.30	6.4	6.30	7.20	7.55	6.45	7.00	7.6	7.65	6.45
CD	NS															

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.19. (c) Interaction between dates of planting and mulches on number of leaves

Mulches	17				19				21				23			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	6.55	7.20	7.35	6.25	7.75	7.75	7.35	6.20	7.50	8.20	7.60	6.20	7.70	8.20	7.60	6.25
M2	6.65	6.70	7.15	6.45	7.30	7.30	7.25	6.35	7.65	7.70	7.45	6.40	7.75	7.70	7.45	6.45
M3	6.85	6.90	7.20	6.60	7.40	7.40	7.25	6.50	8.10	7.80	7.55	6.65	8.15	7.80	7.55	6.60
M4	7.00	7.20	7.65	6.55	7.55	7.55	7.70	6.45	7.80	7.75	7.80	6.45	7.85	7.75	7.80	6.50
CD	NS															

Table 4.19. (d) Interaction between dates of planting and mulches on number of leaves

Mulches	25				27				29			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	7.85	8.20	7.65	6.25	7.85	8.20	7.65	6.25	7.85	8.20	7.65	6.25
M2	8.00	8.05	7.45	6.55	8.00	8.05	7.45	6.55	8.00	8.05	7.45	6.55
M3	8.40	8.00	7.60	6.55	8.40	8.00	7.60	6.55	8.40	8.00	7.60	6.55
M4	8.25	7.85	7.80	6.55	8.25	7.85	7.80	6.55	8.25	7.85	7.80	6.55
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.5.3. Leaf area (cm^2)

Analysis of variance for leaf area of turmeric was done for 30 weeks period and it was presented in Appendix III- page x to xi.

Leaf area at fortnightly intervals showed that influence of date of planting had significance in all observations. During the first week July 1st planted crop and July 15th planted crop showed similar leaf area and were superior from other dates of plantings. 3rd week after planting May 15th planting was also significantly similar with June 1st and July 15th plantings. 5th week after planting July 1st planted crop produced higher leaf area. During 7th and 11th week after planting, leaf area of third date of planting was on par with second date of planting. During 9th week, the third and second dates of planting were superior from others and were significantly similar with each other. 13th, 15th, 23rd and 25th week observations showed that May 1st, May 15th and June 1st date of planted crops showed higher leaf area and were superior from the fourth date of planting. 17th week after planting both first and second date of planting were on par with each other and during 19th, 21st, 27th and 29th week, first date of planting produced significantly higher leaf area. The highest leaf area was recorded during 15th week of crop growth and May 1st, 15th and June 1st date of plantings were similar with each other (Table 4.20. (a) and (b)).

The influence of mulching showed significance in all weeks except 1st, 9th, 13th, 25th and 29th weeks after planting. During 3rd, 7th, 11th, 17th, 19th and 21st weeks after planting paddy straw produced higher leaf area and green leaf mulch was on par with paddy straw mulch. During 5th week after planting both paddy straw and green leaf mulch produced similar leaf area. During the 15th and 23rd weeks after planting paddy straw mulch produced higher leaf area, green leaf and white polythene mulches were on par with paddy straw mulch. The highest leaf area was observed during 15th week after planting (Table 4.21. (a) and (b)).

The interaction between dates of planting and mulching treatments on leaf area found to be non-significant in all observations (Table 4.22. (a) to (e)).

Table 4.20. (a) Effect of dates of planting on leaf area (cm^2)

Date of planting	Leaf area (cm^2)							
	1	3	5	7	9	11	13	15
D1	6.54^{b}	26.97^{b}	85.52^{bc}	86.23^{c}	201.52^{c}	445.75^{bc}	542.80^{a}	807.58^{a}
D2	8.89^{b}	63.07^{a}	101.68^{b}	174.99^{ab}	546.47^{a}	546.16^{ab}	633.77^{a}	782.30^{a}
D3	27.74^{a}	70.74^{a}	144.25^{a}	232.32^{a}	508.90^{a}	661.72^{a}	545.50^{a}	662.61^{a}
D4	26.59^{a}	53.01^{a}	52.93^{c}	110.69^{bc}	326.05^{b}	337.39^{c}	286.98^{b}	274.14^{b}
CD	17.09	25.04	34.19	77.82	110.33	134.46	152.44	155.28

Table 4.20. (b) Effect of dates of planting on leaf area (cm^2)

Date of planting	Leaf area (cm^2)						
	17	19	21	23	25	27	29
D1	745.02^{ab}	766.07^{a}	758.19^{a}	689.44^{a}	710.29^{a}	740.46^{a}	715.83^{a}
D2	782.30^{a}	664.61^{b}	672.85^{b}	649.92^{a}	640.65^{a}	646.20^{b}	628.13^{b}
D3	625.73^{b}	667.90^{b}	655.15^{b}	614.01^{a}	640.08^{a}	622.87^{b}	618.17^{b}
D4	286.98^{c}	295.00^{c}	282.41^{c}	279.63^{b}	271.87^{b}	285.50^{c}	270.40^{c}
CD	134.91	92.84	84.94	97.56	96.11	82.89	87.59

D1 – 1^{st} May, D2 – 15^{th} May, D3 – June 1^{st} and D4 – June 15^{th}

Table 4.21. (a) Effect of mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)							
	1	3	5	7	9	11	13	15
M1	12.02	44.72^{bc}	66.26^{b}	106.90^{c}	371.44	450.24^{b}	505.49	621.94^{ab}
M2	11.86	37.67^{c}	71.39^{b}	125.19^{bc}	354.92	431.01^{b}	478.76	569.33^{b}
M3	23.68	70.53^{a}	130.38^{a}	199.62^{a}	448.84	593.32^{a}	528.22	704.37^{a}
M4	22.20	60.86^{ab}	116.36^{a}	172.51^{ab}	407.75	516.45^{ab}	496.59	631.00^{ab}
CD	NS	21.74	32.57	57.55	NS	96.70	NS	83.21

Table 4.21. (b) Effect of mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)							
	15	17	19	21	23	25	27	29
M1	621.94^{ab}	598.07^{b}	568.62^{bc}	565.47b^{c}	548.20^{ab}	555.45	557.75^{ab}	542.79
M2	569.33^{b}	554.79^{b}	541.73^{c}	528.76^{c}	507.32^{b}	513.85	516.74^{b}	506.18
M3	704.37^{a}	685.28^{a}	659.11^{a}	662.14^{a}	612.16^{a}	620.70	635.62^{a}	616.82
M4	631.00^{ab}	601.88^{ab}	624.13^{ab}	612.24^{ab}	565.32^{ab}	574.88	584.92^{ab}	566.73
CD	83.21	86.36	80.29	83.01	86.21	NS	84.09	NS

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

Table 4.22. (a) Interaction between dates of planting and mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)											
	1^{st} week				3^{rd} week				5^{th} week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	3.39	3.27	24.54	16.35	19.19	34.27	88.69	36.74	59.41	55.53	118.58	31.52
M2	4.14	3.52	26.23	13.57	19.00	37.74	49.61	44.34	54.72	99.05	82.50	49.29
M3	9.01	9.47	21.90	54.35	39.46	98.82	68.28	75.55	141.06	139.70	165.24	75.52
M4	9.12	19.29	38.28	22.10	30.23	81.45	76.38	55.40	86.90	112.44	210.70	55.40
CD	NS											

Table 4.22. (b) Interaction between dates of planting and mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)											
	7^{th} week				9^{th} week				11^{th} week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	58.35	124.61	181.58	63.07	159.83	493.98	498.92	33.01	370.15	493.77	704.23	232.81
M2	58.61	89.84	289.99	62.33	151.00	491.61	438.90	338.17	411.60	491.56	567.94	252.95
M3	141.06	284.32	217.22	155.85	295.43	608.79	559.14	332.00	559.28	608.24	734.20	471.55
M4	86.90	201.17	240.47	161.52	199.83	591.49	538.65	301.03	441.97	591.07	640.51	392.24
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
D1 – 1^{st} May, D2 – 15^{th} May, D3 – June 1^{st} and D4 – June 15^{th}

Table 4.22. (c) Interaction between dates of planting and mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)											
	13th week				15th week				17th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	509.35	646.37	633.43	232.81	786.09	761.41	711.83	228.42	690.93	761.81	706.74	232.81
M2	529.44	628.67	497.29	259.64	766.26	704.58	549.06	257.41	712.30	704.51	542.71	259.64
M3	576.97	632.02	555.19	348.69	848.41	889.33	752.12	327.62	807.91	889.07	695.44	348.69
M4	555.45	628.04	496.10	306.77	829.58	773.89	637.42	283.11	768.93	773.81	558.02	306.77
CD	NS											

Table 4.22. (d) Interaction between dates of planting and mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)											
	19th week				21st week				23rd week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	701.55	615.49	715.19	242.23	701.55	715.79	614.60	229.92	656.96	699.61	611.50	224.72
M2	750.75	597.04	555.78	263.36	719.21	560.55	577.73	257.56	704.92	528.39	543.62	252.72
M3	834.76	681.41	765.29	354.89	834.76	766.93	706.05	340.81	740.42	744.76	626.51	336.94
M4	777.24	764.41	635.32	319.53	777.24	648.13	722.23	301.35	655.45	626.92	674.41	304.51
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.22. (e) Interaction between dates of planting and mulching on leaf area (cm^2)

Mulches	Leaf area (cm^2)											
	25th week				27th week				29th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	690.01	693.94	611.50	218.36	706.47	691.88	598.13	234.54	691.58	677.39	586.11	216.09
M2	705.35	518.88	583.98	247.20	713.09	528.39	561.63	263.87	71458	509.49	555.52	245.14
M3	774.62	725.16	657.70	325.30	820.57	739.46	645.61	336.83	789.46	710.61	646.45	320.79
M4	671.19	624.61	707.13	296.61	721.73	625.07	686.13	306.77	667.70	615.02	684.60	299.61
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.5.4. Number of tillers

Analysis of variance for number of tillers of turmeric was done for 30 weeks period and it was presented in Appendix III- page xii.

The Influence of date of planting on number of tillers didn't show any significance in the first week of tillering. Third date of planting June 1st produced higher number of tillers till 8th week after initiation of active tillering. In the 9th week of initiation of active tillering, first date of planting May 1st was on par with third date of planting June 1st. 10th week after initiation of active tillering, number of tillers were on par in first three dates of planting (May 1st, May 15th and June 1st) and were superior to fourth date of planting June 15th (Table 4.23).

Influence of mulches on number of tillers showed influence only after first week of initiation of active tillering. In the first week of observation, paddy straw mulch produced more number of tillers and green leaves were on par with paddy straw mulch. After first week till harvest, number of tillers did not showed any significance in all mulching treatments (Table 4.24).

Interaction between dates of planting and mulches on number of tillers showed influence after 3rd week of initiation of active tillering. In May 1st, May 15th and June 15th dates of plantings all mulching treatments produced similar number of tillers. In June 1st planted crops white polythene, black polythene and paddy straw mulch produced higher number of tiller and were similar in number (Table 4.25. (a) and (b)).

Table 4.23. Influence of dates of planting on number of tillers

Dates of planting	Weekly number of tillers									
	1	2	3	4	5	6	7	8	9	10
1st May	0.28	0.43^{b}	0.61^{bc}	0.61^{b}	1.48^{b}	1.48^{b}	1.75^{b}	1.48^{b}	1.85^{ab}	1.85^{a}
15th May	0.2	0.6^{b}	0.78^{b}	0.78^{b}	1.71^{b}	1.71^{b}	1.73^{b}	1.71^{b}	1.83^{b}	1.83^{a}
1st June	0.42	1.16^{a}	1.43^{a}	1.43^{a}	2.05^{a}	2.05^{a}	2.07^{a}	2.05^{a}	2.07^{a}	2.07^{a}
15th June	0.27	0.41^{b}	0.56^{c}	0.56^{b}	0.83^{c}	0.83^{c}	0.98^{c}	0.83^{c}	1.21^{c}	1.21^{b}
CD	NS	0.31	0.20	0.49	0.33	0.31	0.28	0.22	0.22	0.24

Table 4.24. Influence of mulching on number of tillers

Mulches	Weekly number of tillers									
	1	2	3	4	5	6	7	8	9	10
White polythene	0.25^{b}	0.65	0.87	0.87	1.5	1.5	1.62	1.5	1.72	1.72
Black polythene	0.22^{b}	0.6	0.75	0.75	1.3	1.38	1.5	1.38	1.62	1.62
Paddy straw	0.42^{a}	0.8	1.02	1.02	1.7	1.7	1.81	1.7	1.91	1.91
Green leaf	0.28^{ab}	0.56	0.75	0.75	1.5	1.5	1.61	1.5	1.71	1.71
CD	0.14	NS								

Table 4.25. (a) Interaction between dates of planting and mulching on number of tillers

Mulches	1st week				2nd week				3rd week				4th week				5th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	0.20	0.05	0.55	0.20	0.40	0.50	1.30	0.40	0.50[a]	0.60[a]	1.85[a]	0.55[a]	0.50	0.60	1.85	0.55	1.15	1.65	2.40	0.80
M2	0.25	0.15	0.35	0.15	0.40	0.50	1.20	0.30	0.50[a]	070[a]	1.40[a]	0.40[a]	0.50	0.70	1.40	0.40	1.40	1.55	1.95	0.65
M3	0.40	0.40	0.55	0.35	0.45	0.75	1.50	0.50	0.70[a]	0.95[a]	1.75[a]	0.70[a]	0.70	0.95	1.75	0.70	1.65	1.80	2.25	1.10
M4	0.30	0.20	0.25	0.40	0.50	0.65	0.65	0.45	0.75[a]	0.90[a]	0.75[b]	0.60[a]	0.75	0.90	0.75	0.60	1.75	1.85	1.60	0.80
CD	NS								0.51				NS							

Table 4.25. (b) Interaction between dates of planting and mulching on number of tillers

Mulches	6th week				7th week				8th week				9th week				10th week			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	1.15	1.65	2.40	0.80	1.40	1.65	2.50	0.95	1.15	1.65	240	0.80	1.55	1.70	2.50	1.15	1.55	1.70	2.50	1.15
M2	1.40	1.55	1.95	0.65	1.65	1.55	1.95	0.85	1.40	1.55	1.95	0.65	1.70	1.80	1.95	1.05	1.70	1.80	1.95	1.05
M3	1.65	1.80	2.25	1.10	1.95	1.85	2.25	1.20	1.65	1.80	2.25	1.10	2.05	1.85	2.25	1.50	2.05	1.85	2.25	1.50
M4	1.75	1.85	1.60	0.80	2	1.90	1.60	0.95	1.75	1.85	1.60	0.80	2.10	2.00	1.60	1.15	2.10	2.00	1.60	1.15
CD	NS																			

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.5.5. Dry matter accumulation (kg ha^{-1})

Analysis of variance was carried out for dry matter accumulation was recorded on monthly basis up to 8th month and was represented in Appendix III- page xiii to xiv.

The influence of dates of planting on dry matter accumulation showed that 2nd and 5th month after planting; May 1st planted crop accumulated more dry matter. In the 3rd month after planting, May 15th date of planting showed higher dry matter accumulation. After 4th month, both May 1st and June 1st dates of planting produced similar dry matter accumulation and were superior from others. In 6th and 7th months, the May 1st and May 15th dates of planting recorded higher dry matter accumulation and were superior from others. In the last month, May 1st, May 15th and June 1st dates of planting recorded higher dry matter accumulation. The highest dry matter accumulation was observed in 6 months after planting (Table 4.26).

The influence of mulching on dry matter accumulation showed that, paddy straw mulching treatment produced higher dry matter accumulation till 8th month after planting. It was on par with green leaf mulch during 4th and 6th months after planting. Both plastic mulching treatments accumulated lesser dry matter than organic mulches (Table 4.27).

The interaction between dates of planting and mulches on dry matter accumulation was found to be significant in 2nd, 3rd, 4th, 5th and 7th months after planting. The dry matter accumulation showed that in all dates of planting organic mulches accumulated more dry matter and were superior than polythene mulches (Table 4.28. (a) to (c)).

Table 4.26. Influence of dates of planting on dry matter accumulation (kg ha^{-1})

Dates of plantings	Dry matter accumulation kg ha^{-1}							
	1st month	2nd month	3rd month	4th month	5th month	6th month	7th month	8th month
1st May	1882.16	2617.66^{a}	3168.91^{bc}	6432.25^{a}	12684.75^{a}	13872.50^{a}	12176.16^{a}	10203.33^{a}
15th May	1497.50	2252.66^{b}	4182.33^{a}	4806.75^{b}	10093.75^{c}	13080.67^{a}	12751.66^{a}	10413.33^{a}
1st June	1781.16	2053.25^{b}	3389.41^{b}	5788.25^{a}	10893.33^{b}	11028.33^{b}	9555.33^{b}	9571.66^{a}
15th June	1642.50	2040.41^{b}	2511.83^{c}	3259.16^{c}	5550^{d}	10971.67^{b}	9183.33^{b}	6911.66^{b}
CD	NS	284	658.8	676.2	373.5	1008.6	1558.6	858.1

Table 4.27. Influence of mulches on dry matter accumulation (kg ha^{-1})

Mulches	Dry matter accumulation kg ha^{-1}							
	1st month	2nd month	3rd month	4th month	5th month	6th month	7th month	8th month
White polythene	1597.50	1939.58^{c}	2594^{c}	4657.83^{b}	9003.08^{c}	11285.00^{b}	10488.83^{c}	8937.50^{c}
Black polythene	1770.33	1844.85^{c}	2678.16^{c}	4209.33^{c}	8558.33^{c}	11157.67^{b}	9860.83^{d}	8655.00^{c}
Paddy straw	1713.50	2749.50^{a}	4396.83^{a}	5864.25^{a}	11523.08^{a}	13392.17^{a}	12173.00^{a}	10033.33^{a}
Green leaf	1722.50	2430.33^{b}	3583.50^{b}	5555^{a}	10137.33^{b}	13118.33^{a}	11143.83^{b}	9474.16^{b}
CD	NS	221.2	305.2	383.0	520.7	758.77	426.2	376.4

Table 4.28. (a) Interaction between dates of planting and mulching on dry matter accumulation (kg ha^{-1})

Mulches	Dry matter accumulation kg ha^{-1}											
	1st month				2nd month				3rd month			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	1733.33	1376.66	1610.00	1670.00	2500^{bc}	2100^{b}	1760^{b}	1398.3^{b}	2456.7^{c}	2220^{c}	3152.6^{bc}	2546.7^{b}
M2	1931.33	1726.66	1880.00	1543.33	2153.3^{c}	2021.3^{b}	1498.3^{b}	1705.3^{b}	3051^{bc}	2482.3^{c}	2895^{c}	2284.3^{b}
M3	1984.00	1506.66	1630.00	1733.33	3094^{a}	2823.3^{a}	2368^{a}	2712.7^{a}	4066.3^{a}	6696.7^{a}	3646.6^{ab}	3177.7^{a}
M4	1880.00	1380.00	2006.66	1623.33	2723.3^{ab}	2066^{b}	2486.7^{a}	2345.3^{a}	3101.7^{b}	5330.3^{b}	3863.3^{a}	2038.7^{b}
CD	NS				442.4				610.5			

Table 4.28. (b) Interaction between dates of planting and mulching on dry matter accumulation (kg ha^{-1})

Mulches	Dry matter accumulation kg ha^{-1}											
	4th month				5th month				6th month			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	6369.7^{b}	4440^{b}	4781.7^{b}	3040^{bc}	11877.3^{b}	9168.3^{c}	10353.3^{b}	4613.3^{c}	11980.0	11800.0	10946.7	10413.3
M2	5584.3^{c}	4166^{b}	4584.3^{b}	2502.7^{c}	11406.7^{b}	9550^{bc}	9186.7^{c}	4090^{c}	12816.7	12004.0	9870.0	9940.0
M3	7786.7^{a}	5337^{a}	7012.7^{a}	3320.7^{b}	13508.3^{a}	11394^{a}	15176.7^{a}	6013.3^{b}	15900.0	13892.0	11783.3	11993.3
M4	5988.3^{bc}	5284^{a}	6774.3^{a}	4173.3^{a}	13946.7^{a}	10262.7^{b}	8856.7^{c}	7483.3^{a}	14793.3	14626.7	11513.3	11540.0
CD	762.1				1041.4				NS			

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.28. (c) Interaction between dates of planting and mulching on dry matter accumulation (kg ha^{-1})

Mulches	Dry matter accumulation kg ha^{-1}							
	7th month				8th month			
	D1	D2	D3	D4	D1	D2	D3	D4
M1	11800.0[b]	12403.3[b]	9192.0[c]	8560.0[c]	9940.0	10126.6	9300.0	6383.3
M2	11200.0[b]	12213.3[b]	7893.3[d]	8136.6[c]	9540.0	9460.0	9110.0	6510.0
M3	13154.6[a]	13900.0[a]	10944.0[a]	10693.3[a]	10916.6	11166.6	10326.6	7723.3
M4	12550.0[a]	12490.0[b]	10192.0[b]	9343.3[b]	10416.6	10900.0	9550.0	7030.0
CD	720.4				NS			

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.6. PHENOLOGICAL OBSERVATIONS

Analysis of variance was carried out for phenology of turmeric was recorded and was represented in Appendix III- page xiii.

4.6.1. Emergence of first tiller

The analysis of variance table number 4.29 of phonological parameters showed significant difference between all dates of planting for emergence of first tiller. The maximum days of 85.5 were taken in May 1st date of planting and the minimum of 54 days were taken in June 15th date of planting. The May 15th date of planting took 72.25 days and June 1st date of planting took 68.75 days and they were also different from all other plantings.

The analysis of variance table number 4.30 of phonological parameters showed significant difference in different mulches. The maximum days of 70.25 was taken in black polythene mulch. The minimum days of 69.25 and 69.75 were taken up by paddy straw and green leaves, and they were on par with each other. The white polythene mulch took 70.25 days for emergence of first tiller and was on par with other mulching treatments.

The analysis of variance table number 4.31 of interaction between the date of plantings and mulches showed no significance in all date of plantings.

4.6.2. Emergence of last tiller

The analysis of variance table number 4.29 of phonological parameters showed significant difference between all dates of planting for emergence of last tiller. The maximum days of 136 was taken in May 1st date of planting and the minimum of 96 days were taken in June 15th date of planting. The May 15th date of planting took 134.25 days and June 1st date of planting took 103 days for emergence of last tiller.

The analysis of variance table number 4.30 of phonological parameters showed significant difference in different mulches. The maximum days of 118.75 and 118 were taken in black polythene and white polythene mulch; they were on par with each other. The minimum days of 116.5 and 116 were taken up by green leaves and paddy straw mulches, and they were on par with each other.

The analysis of variance table number 4.31 of interaction between the date of plantings and mulches showed no significance in all date of plantings.

4.6.3. Duration of the crop

The analysis of variance table number 4.29 of phonological parameters showed significant difference between all dates of planting for duration of the crop. The maximum days of 214.75 and 213.43 were taken by May 1st and 15th dates of planting; they were on par with each other. The minimum of 197.37 days were taken in June 15th date of planting. The June 1st date of planting took 210.81 days and it was also different from all other plantings.

The analysis of variance table number 4.30 of phonological parameters didn't show any significant difference in different mulches.

The analysis of variance table number 4.31 of interaction between the date of plantings and mulches showed significant difference between duration of the crop. In May 1st date of planting the green leaves and paddy straw mulches showed maximum number of days of 215.5 and 215.25 and they were similar. Both organic mulches were on par with black polythene mulch of 214.75 days. The black polythene mulch was on par with 213.50 was taken up by white polythene mulch. The second date of planting May 15th showed that the maximum duration of 214.25 was taken up by black polythene and green leaf mulches. Both these mulches were on par with white polythene mulch of 212.75 days and white polythene mulch was on par with 212.5 days taken by paddy straw mulch. In the case of third date of planting June 1st the maximum number of days to maturity of 211.50 and 211.25 were taken up by white polythene and straw mulches, and they were similar. Both these mulches were on par with 211 days of black polythene mulch. The black polythene mulch was on par with 209.50 days taken up by Green leaves mulch. In the last date of planting June 15th the paddy straw mulch and green leaves took more days (198.25 and 198) and they were similar. Both organic mulches were on par with 197 days of white polythene mulch. The white polythene mulch was on par with 196.2 days taken by black polythene mulch.

Table 4.29. Effect of dates of planting on phenophases

Dates of planting	Emergence of first tiller	Emergence of last tiller	Duration of the crop
D1	85.50^{a}	136.00^{a}	214.75^{a}
D2	72.25^{b}	134.25^{b}	213.43^{a}
D3	68.75^{c}	103.00^{c}	210.81^{b}
D4	54.00^{d}	96.00^{d}	197.37^{c}
CD	0.50	0.50	1.6

Table 4.30. Effect of mulches on phenophases

Mulches	Emergence of first tiller	Emergence of last tiller	Duration of the crop
M1	70.25^{ab}	118.00^{a}	209.06
M2	71.25^{a}	118.75^{a}	208.60
M3	69.25^{b}	116.00^{b}	209.31
M4	69.75^{b}	116.50^{b}	209.31
CD	1.32	1.32	NS

Table 4.31. Interaction between dates of planting and mulches on phenophases

Mulches	Emergence of first tiller				Emergence of last tiller				Duration of the crop			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	86	73	68	54	137	135	96	104	213.50^{b}	212.75^{ab}	211.50^{a}	197.00^{ab}
M2	86	74	70	55	138	136	97	104	214.75^{ab}	214.25^{a}	211.00^{ab}	196.25^{b}
M3	85	70	68	54	134	133	95	102	215.25^{a}	212.50^{b}	211.25^{a}	198.25^{a}
M4	85	72	69	53	135	133	96	102	215.50^{a}	214.25^{a}	209.50^{b}	198.00^{a}
CD	NS								1.6			

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.7. YIELD AND YIELD ATTRIBUTES

Analysis of variance was carried out for yield and yield attributes was recorded and was represented in Appendix II- page xiv.

4.7.1. Length of primary rhizomes (cm)

The analysis of variance of length of primary rhizome of turmeric didn't show any significant difference between different date of plantings, mulches and as an interaction between date of planting and mulches (Table 4.32, 4.33 and 4.34. (a)).

4.7.2. Width of primary rhizome (cm)

The analysis of variance of width of primary rhizome of turmeric showed significant difference between different dates of plantings. The maximum of 1.96 cm was shown in 1st date planting May 1st and it was on par with May 15th, that is 1.93 cm and 1.88 cm of June 1st date of planting. The minimum length of 1.61 cm was shown in June 15th date of planting. The fourth planting June 15th was significantly different from all three plantings (Table 4.32).

The effect of mulches on width of primary rhizome (Table 4.33) and the interactive effect of dates of planting on mulches (Table 4.34. (a)) did not show any significance.

4.7.3. Number of mother rhizome

The analysis of variance of number of mother rhizome of turmeric didn't show any significant difference between different date of plantings, mulches and as an interaction between date of planting and mulches (Table 4.32, 4.33 and 4.34. (b)).

4.6.4. Number of primary rhizomes

The analysis of variance of number of primary rhizome of turmeric didn't show any significant difference between different date of plantings, mulches and as an interaction between date of planting and mulches (Table 4.32, 4.33 and 4.34. (b)).

4.7.5. Number of secondary rhizomes

The analysis of variance, number of secondary rhizome of turmeric showed significant difference between different dates of plantings. The May 1st, May 15th and June 1st dates of planting were similar and they recorded 30.16, 33.07 and 31.68 numbers of secondary rhizomes. The minimum of 23.51 numbers of rhizomes were obtained from June 15th date of planting which was inferior to all the three dates of planting (Table 4.32).

The effect of mulches on number of secondary rhizomes and the interactive effect of dates of planting on mulches did not show any significance (Table 4.33 and 4.34. (b)).

4.7.6. Weight of mother rhizomes (g)

The analysis of variance table number 4.32 of weight of mother rhizome of turmeric showed significant difference between different dates of plantings. The May 1st, May 15th and June 1st dates of plantings were similar and recorded 74.97g, 66.73g and 69.60g weights of mother rhizomes. The minimum weight of 39.75g was shown in June 15th date of planting which was inferior to others.

The effect of mulches on weight of mother rhizomes and the interactive effect of dates of planting on mulches did not show any significance (Table 4.33 and 4.34. (c)).

4.7.7. Weight of primary rhizomes (g)

The analysis of variance table 4.32 of weight of primary rhizome of turmeric showed significant difference between different dates of plantings. The maximum weights of 130.87g, 134.75g and 122.40g were recorded in 1st, 2nd and 3rd dates of planting and they were similar with each other. The minimum weight of 76.22g was recorded in June 15th date of planting. The fourth planting June 15th was inferior to all three plantings.

The effect of mulches on weight of primary rhizomes (Table 4.33) and the interactive effect of dates of planting on mulches (Table 4.34. (c)) did not show any significance.

4.7.8. Weight of secondary rhizomes (g)

The analysis of variance, for weight of secondary rhizome of turmeric showed significant difference between different dates of plantings. The maximum weights of 88.65g, 91.03g and 99.25g were shown in 1st, 2nd and 3rd dates of planting and they were similar with each other. The minimum weight of 41.95g was shown in June 15th date of planting. The fourth planting June 15th was inferior to all three plantings (Table 4.32).

The effect of mulches on weight of primary rhizomes (Table 4.33) and the interactive effect of dates of planting on mulches (Table 4.34. (d)) did not show any significance.

4.7.9. Fresh yield (kg ha^{-1})

The analysis of variance for fresh yield of turmeric showed significant difference between different dates of plantings. The maximum yield of 24891.07 kg ha^{-1} was obtained from 2nd date of planting 15th May and minimum yield of 12117.38 kg ha^{-1} was obtained in 4th date of planting 15th June. The yield of first date of planting 1st May was on par with the second date of planting, which produced a yield of 24388.09 kg ha^{-1}. The fresh yield 19447.07 kg ha^{-1} of 3rd date of planting 1st June was different from 1st and 2nd and 4th date of planting (Table 4.32).

The analysis of variance table of fresh yield of turmeric showed significant difference between different mulches. The maximum and minimum yield of 23952.73 kg ha^{-1} and 16278.71 kg ha^{-1} were produced from paddy straw (M3) and black polythene mulch (M2). The white polythene mulch (M1) produced 19040.82 kg ha^{-1} and the green leaves (M4) produced 21571.68 kg ha^{-1}. All four mulches showed significant difference between yields (Table 4.33).

The analysis of variance table of interaction between the date of plantings and mulches showed no significance in all date of plantings (Table 4.34. (a)).

4.7.10. Dry yield (kg ha^{-1})

The analysis of variance for dry yield of turmeric showed significant difference between different dates of planting. The maximum yield of 4697.68 kg ha^{-1} was obtained from 2nd date of planting 15th May and minimum yield of 2173.89 kg ha $^{-1}$ was obtained in 4th date of planting 15th June. The yield of first date of planting was on par with 4645.78 kg ha^{-1} of the second date of planting on 15th may. The dry yield 3547.44 kg ha^{-1} of 3rd date of planting 1st June was different from 1st and 2nd and 4th dates of planting (Table 4.32).

The analysis of variance table of dry yield of turmeric showed significant difference between different mulches. The maximum and minimum yield of 4543.68 kg ha^{-1} and 2973.27 kg ha^{-1} were produced by paddy straw (M3) and black polythene mulch (M2). The white polythene mulch (M1) produced 3515.27 kg ha^{-1} and the green leaves (M4) produced 4032.56 kg ha^{-1}. All four mulches showed significant difference between yields (Table 4.33).

The interaction between the date of plantings and mulches (Table 4.34. (d)) showed no significance in all date of plantings.

Table 4.32. Effect of dates of planting on yield and yield attributes

Date of planting	Yield and yield parameters									
	Yield (kg ha^{-1})	Length of primary rhizome (cm)	Width of primary rhizome (cm)	Number of mother rhizome	Number of primary rhizome	Number of secondary rhizome	Weight of mother rhizome(g)	Weight of primary rhizome (g)	Weight of secondary rhizome (g)	Dry yield (kg ha^{-1})
1st May	24388.09^{a}	14.75	1.96^{a}	1.87	10.21	30.16^{a}	74.97^{a}	130.87^{a}	88.65^{a}	4645.78^{a}
15th May	24891.41^{a}	11.17	1.93^{a}	2.05	11.86	33.07^{a}	66.73^{a}	134.75^{a}	91.03^{a}	4697.68^{a}
1st June	19447.07^{b}	12.07	1.88^{a}	2.42	12.36	31.68^{a}	69.60^{a}	122.40^{a}	99.25^{a}	3547.44^{b}
15th June	12117.38^{c}	11.30	1.61^{b}	2.56	12.78	23.51^{b}	39.75^{b}	76.22^{b}	41.95^{b}	2173.89^{c}
CD	3836.19	NS	0.10	NS	NS	6.53	11.86	33.66	30.38	731.21

Table 4.33. Effect of mulches on yield and yield attributes

Mulches	Yield and yield parameters									
	Yield (kg ha^{-1})	Length of primary rhizome (cm)	Width of primary rhizome (cm)	Number of mother rhizome	Number of primary rhizome	Number of secondary rhizome	Weight of mother rhizome(g)	Weight of primary rhizome (g)	Weight of secondary rhizome (g)	Dry yield (kg ha^{-1})
M1	19040.82^{c}	10.86	1.85	2.32	12.43	1.85	63.21	118.40	76.57	3515.27^{c}
M2	16278.71^{d}	12.43	1.87	2.28	11.10	1.87	59.70	118.93	69.47	2973.27^{d}
M3	23952.73^{a}	13.12	1.84	2.18	12.32	1.84	69.32	119.22	92.20	4543.68^{a}
M4	21571.68^{b}	12.89	1.83	2.11	11.36	1.83	58.82	107.68	82.63	4032.56^{b}
CD	2280.661	NS	NS	NS	NS	NS	NS	NS	NS	427.77

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

Table 4.34. (a) Interaction between dates of planting and mulches on yield and yield attributes

Mulching	Fresh yield (kg ha^{-1})				Length of primary rhizome (cm)				Width of primary rhizome (cm)			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	2526.56	20810.94	20776.56	12049.22	11.05	11.18	12.46	8.75	1.87	1.96	2.02	1.56
M2	20943.75	19660.94	14444.53	10065.62	11.65	10.92	11.22	15.93	2.02	1.94	1.88	1.63
M3	27473.44	31659.38	22912.50	13765.62	18.81	11.00	10.72	11.97	2.03	1.89	1.86	1.59
M4	26608.59	27434.38	19654.69	12589.06	17.50	11.60	13.90	8.57	1.93	1.94	1.78	1.65
CD	NS											

Table 4.34. (b) Interaction between dates of planting and mulches on yield and yield attributes

Mulching	Number of mother rhizome				Number of primary rhizome				Number of secondary rhizome			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
M1	1.55	2.10	3.05	2.60	9.55	11.85	15.20	13.15	1.87	1.96	2.02	1.56
M2	2.15	2.35	2.30	2.35	9.60	10.70	12.30	11.80	2.02	1.94	1.88	1.63
M3	2.00	1.50	2.40	2.85	10.70	11.40	12.30	14.90	2.03	1.89	1.86	1.59
M4	1.80	2.25	1.95	2.45	11.00	13.50	9.65	11.30	1.93	1.94	1.78	1.65
CD	NS											

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Table 4.34. (c) Interaction between dates of planting and mulches on yield and yield attributes

Mulches	Weight of mother rhizome (g)				Weight of primary rhizome (g)			
	D1	D2	D3	D4	D1	D2	D3	D4
M1	58.9 0	65.55	86.50	41.90	106.50	144.25	153.95	68.90
M2	82.20	63.30	61.00	32.30	144.10	131.20	126.80	73.65
M3	87.60	69.10	73.70	46.90	140.60	134.60	118.75	82.95
M4	71.20	69.00	57.20	37.90	132.30	128.95	90.10	79.40
CD	NS							

Table 4.34. (d) Interaction between dates of planting and mulches on yield and yield attributes

Mulches	Weight of secondary rhizome (g)				Dry yield (kg ha^{-1})			
	D1	D2	D3	D4	D1	D2	D3	D4
M1	71.20	87.70	108.30	39.10	4210.90	3927.06	3768.75	2154.38
M2	73.05	76.55	91.60	36.70	3858.93	3617.85	2618.96	1797.33
M3	118.20	106.20	109.30	35.10	5403.44	6095.64	4197.85	2477.81
M4	92.15	93.70	87.80	56.90	5109.86	5150.15	3604.20	2266.03
CD	NS							

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

4.8. CROP WEATHER RELATION

4.8.1. Influence of weather parameters on biometric characters of plant

4.8.1.1. Correlation between weather parameters and plant height (Table 4.35. (a) and (b))

The correlation between weather parameters and plant height at different phenophases are explained here.

4.8.1.1.1. Planting to germination

The weather parameters on initial stage didn't show significant correlation with plant height in all mulching treatments. The significant correlation was shown only in green leaf mulching treatment. High significant positive correlation was shown by rainfall and rainy days and significant positive correlation (at five percent level) was shown by soil moisture at 5 and 20cm depths. Maximum temperature, sunshine hours, forenoon and afternoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depths showed significant negative correlation ($p<0.05$) with plant height (Table 4.35. (a) and (b)).

4.8.1.1.2. Germination to initiation of active tillering

During the second phenophase, high significant positive correlation ($p<0.01$) in white polythene mulch was shown by maximum temperature, rainy days, evaporation, forenoon and afternoon soil temperatures at 5 and 20cm depths and forenoon relative humidity inside plant canopy. Significant positive correlation ($p<0.05$) was shown by minimum temperature. High significant negative correlation ($p<0.01$) with plant height was shown by forenoon and afternoon relative humidity, wind speed, rainfall, afternoon relative humidity inside plant canopy and soil moisture at 5 and 20cm depths. In black polythene mulch high significant positive correlation ($p<0.01$) was shown by maximum temperature, minimum temperature, rainy days, evaporation, forenoon relative humidity inside plant canopy, forenoon and afternoon soil temperature at 5 and 20cm depths. In black polythene mulch high significant negative correlation was shown by forenoon and afternoon relative humidity, wind speed, rainfall, afternoon relative humidity inside plant canopy, soil moisture at 5 and 20cm depths (Table 4.35. (a) and (b)).

In paddy straw mulch high significant positive correlation ($p<0.01$) of was shown by afternoon soil temperature at 20cm and significant positive correlation ($p<0.05$) was shown by rainy days. High significant negative correlation was shown by wind speed, sunshine hours, afternoon soil temperature at 5cm depth and forenoon and afternoon relative humidity. In green leaf mulch rainfall showed high significant positive correlation with plant height. Rainy days and evaporation showed significant positive correlations with plant height. High significant negative correlation ($p<0.01$) was shown by sunshine hours and after noon soil temperature at 5cm (Table 4.35. (a) and (b)).

4.8.1.1.3. Active tillering to bulking

In third phenophase of white polythene mulch showed high significant positive correlation ($p<0.01$) with forenoon and afternoon relative humidity of air and plant canopy, rainfall and soil moisture at 5 and 20cm depths. High significant negative correlation ($p<0.01$) with plant height was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depths and afternoon soil temperature at 5 and 20cm depths. In black polythene mulch high significant positive correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days and soil moisture at 5 and 20cm depths. Significant positive correlation ($p<0.05$) was shown by minimum temperature on plant height. High significant negative correlation with plant height was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depths and afternoon soil temperature at 5 and 20cm depths.

The paddy straw mulch showed high significant positive correlation (one percent level) with minimum temperature, forenoon and afternoon relative humidity of air and plant canopy, rainfall and soil moisture at 5 and 20cm depths. High significant negative correlation was shown by maximum temperature, wind speed, sunshine hours, evaporation, fore noon soil temperature at 5cm depth and after noon soil temperature at 20cm depths. Significant negative correlation ($p<0.05$) was shown by afternoon soil temperature at 5cm depth. In case of green leaf mulching treatment the high significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy and soil moisture at 5 and 20cm depths. High significant negative correlation ($p<0.01$) was shown by maximum temperature, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20 cm depths. Wind speed showed significant negative correlation (at five percent level) with plant height.

4.8.1.1.4. Bulking to physiological maturity

In fourth phenophase, white polythene mulch showed high significant positive correlation with forenoon and afternoon relative humidity of air and plant canopy, rainy days, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth and soil moisture at 5 and 20cm depths. Significant correlation (at five percent level) was shown by rainfall and plant height. High significant negative correlation ($p<0.01$) with plant height was shown by wind speed, sunshine hours, evaporation, fore noon soil temperature at 20cm depths. In black polythene mulch high significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, fore noon soil temperature at 5cm depth and soil moisture at 5 and 20cm depths. Wind speed, evaporation and forenoon soil temperature at 20cm depth showed high significant negative correlation with plant height ($p<0.01$). Sunshine hours showed significant negative correlation ($p<0.05$) with plant height.

The paddy straw mulch showed high significant positive correlation (at one percent level) with forenoon and afternoon relative humidity of air and plant canopy, rainy days, fore noon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth and soil moisture at 5 and 20cm depths. Rainfall showed significant positive correlation ($p<0.05$). High significant negative correlation (one percent level) was shown by wind speed. Significant negative correlation was shown by evaporation, after noon soil temperature at 20cm depths ($p<0.05$). In case of green leaf mulching treatment high significant positive correlation (at one percent level) was shown by forenoon relative humidity of air and plant canopy, afternoon relative humidity of plant canopy, forenoon soil temperature at 5cm depth, after noon soil temperature at 20cm depth and soil moisture at 5 and 20cm depths. Significant positive correlation ($p<0.05$) was shown by afternoon relative humidity of air, rainfall, rainy days and fore noon soil temperature at 20cm depth. Wind speed showed high significant negative correlation with plant height (Table 4.35. (a) and (b)).

Table 4.35. (a) Correlation between weather parameters and plant height

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.168	0.3	-0.108	0.043	0.43	0.205	0.128	0.146	0.213
	M2	0.306	0.338	-0.293	-0.177	0.475	-0.188	0.078	0.239	0.364
	M3	-0.119	-0.057	0.134	0.123	0.05	0.161	0.337	-0.119	0.041
	M4	-0.517*	-0.461	0.445	0.463	-0.371	0.661**	0.666**	-0.510*	-0.244
P2	M1	0.818**	0.585*	-0.867**	-0.911**	-0.917**	-0.934**	0.686**	0.377	0.737**
	M2	0.957**	0.965**	-0.951**	-0.958**	-0.956**	-0.970**	0.840**	0.437	0.838**
	M3	0.389	0.34	-0.634**	-0.769**	-0.779**	0.376	0.515*	-0.687**	0.346
	M4	0.178	0.285	-0.126	0.286	-0.313	0.666**	0.606*	-0.714**	0.565*
P3	M1	-0.885**	0.462	0.878**	0.838**	-0.753**	0.878**	0.232	-0.774**	-0.785**
	M2	-0.894**	0.588*	0.850**	0.888**	-0.695**	0.937**	0.808**	-0.837**	-0.788**
	M3	-0.849**	0.649**	0.834**	0.852**	-0.748**	0.772**	0.427	-0.757**	-0.684**
	M4	-0.862**	0.433	0.846**	0.747**	-0.574*	0.392	0.318	-0.656**	-0.686**
P4	M1	0.244	-0.389	0.757**	0.674**	-0.807**	0.552*	0.625**	-0.066	-0.824**
	M2	0.033	-0.364	0.825**	0.765**	-0.861**	0.637**	0.707**	-0.529*	-0.861**
	M3	0.171	0.036	0.696**	0.646**	-0.739**	0.579*	0.639**	-0.173	-0.525*
	M4	0.247	0.006	0.639**	0.602*	-0.673**	0.553*	0.610*	-0.288	-0.387

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.35. (b) Correlation between weather parameters and plant height

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.124	0.08	0.116	0.181	-0.257	-0.257	-0.098	0.032
	M2	0.291	0.362	0.249	0.322	-0.135	-0.207	-0.293	-0.163
	M3	-0.08	-0.109	-0.119	-0.205	0.13	0.16	0.129	0.126
	M4	-.539*	0.392	-0.515*	-0.557*	0.564*	0.568*	0.471	0.452
P2	M1	0.667**	0.847**	0.944**	0.870**	-0.627**	-0.627**	0.698**	-0.673**
	M2	0.974**	0.957**	0.930**	0.847**	-0.897**	-0.952**	0.849**	-0.822**
	M3	0.312	0.473	-0.615*	0.709**	0.663**	0.699**	0.639**	-0.314
	M4	0.234	0.413	-0.692**	0.193	0.673**	0.689**	0.557*	0.41
P3	M1	-0.742**	-0.245	-0.889**	-0.957**	0.690**	0.671**	0.894**	0.833**
	M2	-0.816**	-0.169	-.698**	-0.927**	0.756**	0.807**	0.877**	0.880**
	M3	-0.665**	0.049	-.536*	-0.855**	0.787**	0.781**	0.852**	0.842**
	M4	-0.825**	-0.808**	-.840**	-0.904**	0.707**	0.716**	0.809**	0.715**
P4	M1	0.868**	-0.790**	0.177	0.847**	0.752**	0.739**	0.782**	0.742**
	M2	0.797**	-0.891**	-0.251	0.19	0.783**	0.803**	0.850**	0.819**
	M3	0.900**	-0.557*	0.431	0.771**	0.761**	0.761**	0.696**	0.694**
	M4	0.893**	0.529*	0.339	0.871**	0.744**	0.744**	0.645**	0.667**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.1.2. Correlation between weather parameters and number of leaves

The correlation between weather parameters and number of leaves at different phenophases are explained here.

4.8.1.2.1. Planting to germination

In the first phenophase of turmeric, white polythene mulch showed high significant positive correlation (one percent level) with maximum and minimum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. High significant negative correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days and soil moisture at 5 and 20cm depths. In case of black polythene mulch weather variables like maximum and minimum temperature, wind speed, evaporation, forenoon and afternoon soil temperature at 20 cm depths showed significant positive correlation ($p<0.05$) (Table 4.36. (a) and (b)).

Paddy straw mulch showed significant positive correlation with evaporation ($p<0.05$). In case of green leaf mulch the high significant positive correlation (one percent level) was shown by rainfall and rainy days, forenoon soil temperature at 20cm depth and afternoon relative humidity inside plant canopy. Five percent level significant positive correlation was shown by forenoon and afternoon relative humidity of air, soil moisture at 5 and 20cm depths and forenoon relative humidity of plant canopy. High significant negative correlation was shown by maximum and minimum temperature, wind speed, sunshine hours and afternoon soil temperature at 5 and 20cm depths. Significant negative correlation ($p<0.05$) was shown by forenoon soil temperature at 5cm depth (Table 4.36. (a) and (b)).

4.8.1.2.2. Germination to initiation of active tillering

In the second phenophase white polythene mulch showed high significant positive correlation (one percent level) with afternoon soil temperature at 5cm depth. Significant positive correlation ($p<0.05$) was shown by maximum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth and forenoon relative humidity of plant canopy. High significant negative correlation ($p<0.01$) was shown by wind speed and rainfall. Forenoon and afternoon relative humidity of air showed significant negative correlation (five percent level). In case of black polythene mulch weather variables like maximum and minimum temperature, rainy days, afternoon soil temperature at 5 and 20 cm depths and forenoon relative humidity in plant canopy showed significant positive correlation (five percent level). High significant positive correlation ($p<0.01$) was shown by evaporation and forenoon soil temperature at 5 and 20cm depths. One percent level high significant negative correlation was shown by fore noon and afternoon relative humidity and wind speed. Significant negative correlation (Five percent level) was shown by rainfall, soil moisture at 5 and 20cm depths and afternoon relative humidity of plant canopy.

Paddy straw mulch showed significant positive correlation ($p<0.05$) with afternoon soil temperature at 20cm depths and forenoon relative humidity of plant canopy. Significant negative correlation ($p<0.05$) was shown by afternoon relative humidity and wind speed. In case of green leaf mulch the high significant positive correlation (one percent level) was shown by rainfall. Significant positive correlation was shown by soil moisture at 5 and 20cm depths. High significant negative correlation was shown by afternoon soil temperature at 5cm depths (Table 4.36. (a) and (b)).

4.8.1.2.3. Active tillering to bulking

In the third phenophase of turmeric, the white polythene mulch showed significant positive correlation (one percent level) with forenoon and afternoon relative humidity of air and plant canopy, rainfall and soil moisture at 5 and 20cm depth. Five percent level significant positive correlation was shown by minimum temperature. High significant negative correlation ($p<0.01$) was shown by maximum temperature, wind speed sunshine hours, evaporation, forenoon soil temperature at

5cm depth and afternoon soil temperature at 5 and 20cm depth. In case of black polythene mulch minimum temperature showed significant positive correlation (five percent level). High significant positive correlation (one percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall and rainy days and soil moisture at 5 and 20cm depths. High significant negative correlation (one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation, fore noon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. Significant negative correlation was shown by afternoon soil temperature at 5cm depths ($p<0.05$).

Paddy straw mulch showed high significant positive correlation ($p<0.01$) with minimum temperature, forenoon and afternoon relative humidity of air and plant canopy, soil moisture at 5 and 20cm depths. High significant negative correlation ($p<0.01$) was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. In case of green leaf mulch the high significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall and soil moisture at 5 and 20cm depths. High significant negative correlation (one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 20cm depth and forenoon soil temperature at 5cm depth. Afternoon soil temperature at 5cm depth showed significant negative correlation (5 percent level) (Table 4.36. (a) and (b)).

4.8.1.2.4. Bulking to physiological maturity

In the fourth phenophase of turmeric, white polythene mulch showed high significant positive correlation ($p<0.01$) with forenoon relative humidity of air, forenoon and afternoon relative humidity of plant canopy, soil temperature at 5 and 20cm depths, and soil moisture at 5 and 20cm depth. Significant positive correlation ($p<0.05$) was shown by afternoon relative humidity and rainy days. High significant negative correlation ($p<0.01$) was shown by wind speed, evaporation and forenoon soil temperature at 20cm depth. In case of black polythene mulch rainfall and rainy days showed significant positive correlation (at five percent level). High significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, forenoon soil temperature at 5cm depth and soil moisture at 5 and 20cm depths. High significant negative correlation was shown by wind speed, evaporation, fore noon soil temperature at 20cm depth. High significant negative correlation was shown by wind speed, evaporation and forenoon soil temperature at 20cm depths.

Paddy straw mulch showed high significant positive correlation with forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth and soil moisture at 5 and 20cm depths. High significant negative correlation was shown by wind speed, evaporation, and forenoon soil temperature at 20cm depth. In case of green leaf mulch the significant positive correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 20cm depth. Significant positive correlation (at five percent level) was shown by soil moisture at 5 and 20cm depths. High significant negative correlation ($p<0.01$) was shown by wind speed and sunshine hours showed significant negative correlation ($p<0.01$) (Table 4.36. (a) and (b)).

Table 4.36. (a) Correlation between weather parameters and number of leaves

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.907**	0.870**	-0.899**	-0.792**	0.846**	-0.600*	-0.702**	0.896**	0.923**
	M2	0.501*	0.512*	-0.494	-0.388	0.613*	-0.399	-0.14	0.44	0.555*
	M3	0.306	0.224	-0.366	-0.396	0.258	-0.203	-0.007	0.278	0.582*
	M4	-0.671**	-0.802**	0.592*	0.620*	-0.879**	0.655**	0.634**	-0.707**	-0.4
P2	M1	0.599*	0.455	-0.622*	-0.609*	-0.638**	-0.653**	0.523*	0.194	0.554*
	M2	0.614*	0.620*	-0.637**	-0.645**	-0.650**	-0.605*	0.557*	0.363	0.645**
	M3	0.345	0.32	-0.491	-0.574*	-0.500*	0.291	0.441	-0.510*	0.322
	M4	-0.084	0.026	0.131	0.454	-0.09	0.634**	0.401	-0.550*	0.349
P3	M1	-0.916**	0.518*	0.923**	0.879**	-0.818**	0.812**	0.223	-0.814**	-0.830**
	M2	-0.811**	0.509*	0.801**	0.801**	-0.709**	0.822**	0.693**	-0.747**	-0.733**
	M3	-0.897**	0.732**	0.863**	0.903**	-0.813**	0.544*	0.142	-0.859**	-0.838**
	M4	-0.813**	0.468	0.870**	0.709**	-0.762**	0.029	-0.105	-0.625**	-0.827**
P4	M1	0.356	-0.342	0.671**	0.580*	-0.732**	0.479	0.539*	0.088	-0.743**
	M2	0.057	-0.393	0.702**	0.645**	-0.741**	0.561*	0.607*	-0.413	-0.722**
	M3	0.013	-0.102	0.808**	0.785**	-0.832**	0.756**	0.775**	-0.363	-0.645**
	M4	0.07	-0.013	0.678**	0.684**	-0.691**	0.663**	0.661**	-0.567*	-0.424

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.36. (b) Correlation between weather parameters and number of leaves

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.887**	0.878**	0.888**	0.896**	-0.784**	-0.784**	-0.893**	-0.801**
	M2	0.49	0.553*	0.455	0.512*	-0.311	-0.375	-0.495	-0.375
	M3	0.354	0.4	0.322	0.301	-0.32	-0.293	-0.37	-0.393
	M4	-0.585*	0.872**	-0.661**	-0.620*	0.542*	0.537*	0.569*	0.638**
P2	M1	0.505*	0.615*	0.646**	0.617*	-0.487	-0.487	0.525*	-0.406
	M2	0.633**	0.641**	0.616*	0.517*	-0.525*	-0.598*	0.539*	-0.596*
	M3	0.308	0.407	-0.386	0.521*	0.452	0.458	0.513*	-0.201
	M4	-0.03	0.149	-0.760**	-0.069	0.598*	0.607*	0.347	0.492
P3	M1	-0.793**	-0.19	-0.841**	-0.950**	0.774**	0.747**	0.919**	0.873**
	M2	-0.764**	-0.18	-0.602*	-0.818**	0.742**	0.769**	0.811**	0.792**
	M3	-0.792**	0.102	-0.446	-0.896**	0.836**	0.862**	0.870**	0.894**
	M4	-0.824**	-0.848**	-0.600*	-0.860**	0.849**	0.838**	0.849**	0.667**
P4	M1	0.911**	-0.682**	0.279	0.905**	0.659**	0.650**	0.697**	0.662**
	M2	0.773**	-0.768**	-0.214	0.214	0.649**	0.677**	0.725**	0.696**
	M3	0.911**	-0.643**	0.201	0.639**	0.743**	0.743**	0.808**	0.815**
	M4	0.846**	0.636**	0.01	0.643**	0.607*	0.607*	0.683**	0.723**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.1.3. Correlation between weather parameters and leaf area

The correlation between weather parameters and leaf area at different phenophases are explained here.

4.8.1.3.1. Planting to germination

Influence of weather parameters with leaf area in first phenophase, white polythene, black polythene and green leaf mulching treatments didn't show any significant correlation with weather parameters. Paddy straw mulch showed significant positive correlation ($p<0.05$) with maximum and minimum temperature, wind speed, sunshine hours, forenoon and afternoon soil temperature at 5 and 20cm depths. Significant negative correlation ($p<0.05$) was shown by fore noon relative humidity of air and plant canopy, rainfall, rainy days and soil moisture at 5 and 20cm depths (Table 4.37. (a) and (b)).

4.8.1.3.2. Germination to initiation of active tillering

The white polythene mulching treatment showed high significant positive correlation (one percent level) with maximum and minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity inside plant canopy. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air, wind speed, rainfall soil moisture at 5 and 20cm depths and forenoon relative humidity inside plant canopy. Black polythene mulch showed high significant positive correlation (one percent level) with maximum and minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity of plant canopy. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air, wind speed, rainfall, soil moisture at 5 and 20cm depths and afternoon relative humidity of plant canopy.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by rainfall and soil moisture at 5 and 20cm depths. High significant positive correlation was shown by maximum and minimum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 20cm depths and forenoon relative humidity inside plant canopy. Significant negative correlation was shown by wind speed. High significant negative correlation was shown by forenoon and afternoon relative humidity of air and sunshine hours. The green leaf mulching treatment showed high significant positive correlation (one percent level) in maximum and minimum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 20cm depth and forenoon relative humidity of plant canopy. High significant negative correlation (one percent level) was shown by forenoon relative humidity of air, wind speed and sunshine hours (Table 4.37. (a) and (b)).

4.8.1.3.3. Active tillering to bulking

The white polythene mulch showed high significant positive correlation with fore noon and afternoon relative humidity of air and plant canopy and soil moisture at 5 and 20cm depths. Significant positive correlation (five percent level) was shown by rainfall. High significant negative correlation was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 5 and 20 cm depths. The black polythene mulch showed high significant positive correlation with minimum temperature, fore noon and afternoon relative humidity of air and plant canopy, rainfall and soil moisture at 5 and 20cm depths. High significant negative correlation was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20 cm depths.

The paddy straw mulch showed high significant positive correlation with fore noon and afternoon relative humidity of air and plant canopy and soil moisture at 5 and 20cm depths. Minimum temperature showed significant positive correlation ($p<0.05$). High significant negative correlation (one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20 cm depth. Significant negative correlation ($p<0.05$) was shown by afternoon soil temperature at 5cm depth. The green leaf mulch showed high significant positive correlation (one percent level) with minimum temperature, fore noon and afternoon relative humidity of air and plant canopy and soil moisture at 5 and 20cm depths. High significant negative correlation (one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5 and 20cm depth and afternoon soil temperature at 20 cm depth (Table 4.37. (a) and (b)).

4.8.1.3.4. Bulking to physiological maturity

In white polythene mulch high significant positive correlation (one percent level) was shown by forenoon relative humidity of air and plant canopy, fore noon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, soil moisture at 5 and 20cm depth and afternoon relative humidity of plant canopy. Significant positive correlation ($p<0.05$) was shown by afternoon relative humidity, rainfall and rainy days. High negative correlation (one percent level) was shown by wind speed, evaporation and fore noon soil temperature at 20cm depth. In black polythene mulch high significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 5cm depth and soil moisture at 5 and 20cm depth. High significant negative correlation ($p<0.01$) was shown by minimum temperature, wind speed, evaporation and fore noon soil temperature at 20cm depth.

In paddy straw mulch high significant positive correlation (one percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainy days and forenoon soil temperature at 5cm depth. Significant positive correlation ($p<0.05$) was shown by rainfall, afternoon soil temperature at 20cm depths and soil moisture at 5 and 20cm depths. High negative correlation (one percent level) was shown by wind speed. In green leaf mulch significant positive correlation (one percent level) was shown by fore noon soil temperature at 5 and 20cm depth. Significant positive correlation ($p<0.05$) was shown by afternoon soil temperature at 20cm depth and leaf area (Table 4.37. (a) and (b)).

Table 4.37. (a) Correlation between weather parameters and leaf area

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	-0.007	0.017	0.009	0.164	0.139	0.308	0.242	-0.033	0.043
	M2	0.142	0.214	-0.081	-0.091	0.239	-0.059	-0.015	0.146	0.112
	M3	0.566*	0.594*	-0.517*	-0.497	0.568*	-0.592*	-0.584*	0.578*	0.438
	M4	0.37	0.452	-0.305	-0.326	0.493	-0.402	-0.387	0.394	0.158
P2	M1	0.881**	0.651**	-0.800**	-0.627**	-0.749**	-0.832**	0.848**	0.097	0.867**
	M2	0.785**	0.790**	-0.770**	-0.767**	-0.769**	-0.800**	0.691**	0.305	0.637**
	M3	0.667**	0.654**	-0.788**	-0.849**	-0.523*	0.504*	0.794**	-0.705**	0.651**
	M4	0.721**	0.750**	-0.680**	-0.321	-0.716**	0.324	0.736**	-0.678**	0.746**
P3	M1	-0.835**	0.471	0.892**	0.808**	-0.864**	0.621*	0.283	-0.734**	-0.761**
	M2	-0.909**	0.748**	0.892**	0.911**	-0.841**	0.766**	0.475	-0.903**	-0.942**
	M3	-0.851**	0.565*	0.851**	0.817**	-0.842**	0.443	0.128	-0.753**	-0.790**
	M4	-0.837**	0.662**	0.872**	0.801**	-0.709**	0.026	-0.212	-0.752**	-0.896**
P4	M1	0.24	-0.451	0.687**	0.611*	-0.739**	0.551*	0.588*	0.029	-0.739**
	M2	-0.132	-0.736**	0.728**	0.688**	-0.765**	0.711**	0.700**	-0.459	-0.699**
	M3	0.098	-0.001	0.656**	0.636**	-0.682**	0.612*	0.624**	-0.236	-0.494
	M4	0.22	0.187	0.43	0.447	-0.442	0.432	0.415	-0.453	-0.176

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.37. (b) Correlation between weather parameters and leaf area

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	-0.049	-0.061	-0.048	-0.025	0.073	0.073	0.023	0.156
	M2	0.127	0.119	0.095	0.162	-0.269	-0.271	-0.084	-0.092
	M3	0.558*	0.507*	0.558*	0.507*	-0.553*	-0.553*	-0.517*	-0.497
	M4	0.319	-0.495	0.363	0.346	-0.298	-0.296	-0.296	-0.335
P2	M1	0.695**	0.836**	0.748**	0.878**	-0.831**	-0.831**	0.725**	-0.267
	M2	0.792**	0.775**	0.745**	0.690**	-0.759**	-0.787**	0.707**	-0.634**
	M3	0.653**	0.746**	-0.359	0.773**	0.608*	0.569*	0.844**	-0.158
	M4	0.749**	0.821**	-0.111	0.723**	0.432	0.458	0.725**	-0.074
P3	M1	-0.735**	-0.169	-0.689**	-0.824**	0.795**	0.744**	0.876**	0.799**
	M2	-0.735**	0.084	-0.347	-0.760**	0.951**	0.950**	0.840**	0.913**
	M3	-0.828**	-0.1	-0.547*	-0.850**	0.848**	0.856**	0.848**	0.788**
	M4	-0.867**	-0.887**	-0.403	-0.819**	0.836**	0.898**	0.887**	0.770**
P4	M1	0.891**	-0.665**	0.154	0.827**	0.671**	0.668**	0.706**	0.686**
	M2	0.855**	-0.774**	-0.429	0.073	0.651**	0.699**	0.742**	0.723**
	M3	0.793**	-0.492	0.248	0.610*	0.599*	0.599*	0.657**	0.665**
	M4	0.629**	0.660**	0.074	0.577*	0.362	0.362	0.436	0.484

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.1.4. Correlation between weather parameters and number of tillers

The correlation between weather parameters and number of tillers at different phenophases are explained here.

4.8.1.4.1. Planting to germination

In the first phenophase no tillers were produced in any mulching treatments (Table 4.38. (a) and (b)).

4.8.1.4.2. Germination to initiation of active tillering

In the second phenophase only white polythene mulch and black polythene mulch showed correlation with weather parameters. White polythene mulch showed significant positive correlation ($p<0.05$) with sunshine hours and high significant negative correlation ($p<0.01$) with afternoon relative humidity of plant canopy. Black polythene mulch showed significant positive correlation with sunshine hours (Table 4.38. (a) and (b)).

4.8.1.4.3. Active tillering to bulking

In white polythene mulch correlation with tiller production and weather parameters showed that rainy days, fore noon relative humidity of air and plant canopy had high significant positive correlation (one percent level). Significant positive correlation (five percent level) was shown by rainfall. High significant negative correlation was shown by wind speed, fore noon soil temperature at 20cm depth and afternoon soil temperature at 5cm depth. Significant negative correlation (five percent level) was shown by soil temperature at 20cm depth. In black polythene mulch correlation of weather parameters showed that forenoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5 and 20cm depth had high significant positive correlation. Significant positive correlation (five percent level) was shown by afternoon relative humidity of air and plant canopy. High significant negative correlation ($p<0.01$) was shown by maximum temperature, wind speed, fore noon soil temperature at 5cm depth and afternoon soil temperature at 5 and 20cm depth. Significant negative correlation ($p<0.05$) was shown by sunshine hours and evaporation.

Paddy straw didn’t show any significant positive or negative correlation. The green leaf mulching treatment showed high significant positive correlation ($p<0.01$) with minimum temperature, fore noon and afternoon relative humidity of air and plant canopy and soil moisture at 20cm depth. Significant correlation (five percent level) was shown by soil moisture at 5cm depth. High significant negative correlation was shown by maximum temperature, sunshine hours, evaporation, forenoon soil temperature at 5 and 20cm depths and afternoon soil temperature 20cm depths. Significant negative correlation was shown by afternoon soil temperature at 5cm depth (Table 4.38. (a) and (b)).

4.8.1.4.4. Bulking to physiological maturity

The number of tillers didn’t change from the third phenophase. No new tillers were produced in the fourth phenophase (Table 4.38. (a) and (b)).

Table 4.38. (a) Correlation between weather parameters and number of tillers

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P2	M1	-0.217	-0.217	-0.019	-0.444	-0.211	-0.092	-0.396	0.525*	-0.337
	M2	0.008	0.033	-0.059	-0.231	-0.108	-0.033	-0.124	0.614*	0.427
	M3	-0.32	-0.368	0.206	0.178	-0.193	-0.072	-0.38	0.19	-0.353
	M4	-0.048	0.002	0.068	0.211	-0.03	0.285	0.173	-0.241	0.149
P3	M1	-0.459	-0.14	0.655**	0.383	-0.811**	0.581*	0.800**	-0.237	-0.285
	M2	-0.648**	0.213	0.714**	0.617*	-0.709**	0.710**	0.694**	-0.518*	-0.534*
	M3	-0.42	0.148	0.454	0.366	-0.478	0.198	0.112	-0.303	-0.365
	M4	-0.804**	0.652**	0.752**	0.796**	-0.413	0.388	0.184	-0.764**	-0.689**

Table 4.38. (b) Correlation between weather parameters and number of tillers

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P2	M1	-0.152	-0.085	0.27	-0.105	0.468	0.468	-0.151	-0.716**
	M2	0.103	0.078	0.279	0.277	0.164	0.024	-0.162	-0.447
	M3	-0.409	-0.346	-0.165	-0.089	0.113	0.206	-0.315	-0.017
	M4	-0.023	0.057	-0.344	-0.041	0.267	0.27	0.149	0.226
P3	M1	-0.235	-0.694**	-0.701**	-0.616*	0.394	0.271	0.789**	0.363
	M2	-0.757**	-0.423	-0.662**	-0.722**	0.629**	0.632**	0.735**	0.600*
	M3	-0.466	-0.245	-0.41	-0.422	0.47	0.453	0.445	0.333
	M4	-0.793**	-0.767**	-0.498*	-0.751**	0.592*	0.704**	0.767**	0.785**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days, EVP- Evaporation, STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.2. Correlation between weather parameters and phenophases

4.8.2.1. Four phenophases

The correlation between weather parameters and days to each phenophases are explained here (Table 4.39. (a) and (b)).

4.8.2.1.1. Planting to germination

The correlation between days to first phenophase and weather variables show that in white polythene mulch high significant positive correlation ($p<0.01$) was shown by maximum temperature, minimum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. Significant negative correlation ($p<0.05$) was shown by rainfall. Forenoon and afternoon relative humidity of air and inside plant canopy, rainy days, soil moisture at 5 and 20cm depths showed high significant correlation ($p<0.01$). In black polythene mulch the high significant positive correlation ($p<0.01$) was shown by maximum and minimum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture of 5 and 20cm depths.

In paddy straw mulch significant positive correlation was shown by wind speed. High significant positive correlation ($p<0.01$) was shown by maximum and minimum temperature, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. Significant negative correlation ($p<0.05$) was shown by rainy days and High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and inside plant canopy, rainfall, soil moisture at 5 and 20cm depth. In green leaf mulch significant positive correlation ($p<0.05$) was shown by sunshine hours. High significant positive correlation was shown by maximum temperature, evaporation, forenoon soil temperature at 5cm depth, afternoon soil temperature at 5 and 20cm depths. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5 and 20cm depths.

4.8.2.1.2. Germination to initiation of active tillering

In white polythene mulch high significant positive correlation ($p<0.01$) was shown by maximum and minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity inside plant canopy. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity of air, wind speed rainfall and soil moisture at 5 and 20cm depths. In black polythene mulch high significant positive correlation (one percent level) was shown by maximum and minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths, forenoon relative humidity inside plant canopy. High significant negative correlation (one percent level) was shown by forenoon and afternoon relative humidity of air, afternoon relative humidity of plant canopy, wind speed, rainfall and soil moisture at 5 and 20cm depths.

In paddy straw mulch high significant positive correlation was shown by maximum and minimum temperature, rainfall, rainy days, evaporation, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth and forenoon relative humidity of plant canopy. Significant negative correlation was shown by sunshine hours. High significant negative correlation was shown by forenoon and afternoon relative humidity of air. In green leaf mulch rainfall showed significant positive correlation (five percent level). Maximum temperature, minimum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20 cm depth, afternoon soil temperature at 20 cm depth, soil moisture at 5and 20cm depth and forenoon relative humidity of plant canopy showed a high significant positive correlation (at one percent level). High significant negative correlation ($p<0.01$) was shown by forenoon relative humidity and sunshine hours.

4.8.2.1.3. Active tillering to bulking

In white polythene mulch maximum temperature, rainy days, sunshine hours, evaporation and forenoon soil temperature at 5cm depth showed high significant positive correlation (one percent level). Significant negative correlation (five percent level) was shown by soil moisture at 5cm depth. High significant negative correlation (one percent level) was shown by minimum temperature, afternoon relative humidity of air and plant canopy, forenoon soil temperature at 20cm depth, soil moisture at 5 and 20cm depths. In black polythene mulch Maximum temperature showed significant positive correlation ($p<0.05$). Sunshine hours and evaporation showed high significant positive correlation (at one percent level). Significant negative correlation was showed by afternoon relative humidity of air and plant canopy. High significant negative correlation ($p<0.01$) was showed by minimum temperature and forenoon soil temperature at 20cm depth.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by forenoon soil temperature at 5cm depth. Rainy days, sunshine hours and evaporation showed high significant positive correlation ($p<0.01$). Significant negative correlation ($p<0.05$) was shown by forenoon and afternoon relative humidity of air and plant canopy. High significant negative correlation ($p<0.01$) was shown by minimum temperature. In green leaf mulch rainfall, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth showed significant positive correlation ($p<0.05$). Wind speed, rainy days, evaporation and forenoon soil temperature at 20cm depth showed a high significant positive correlation ($p<0.01$). High significant negative correlation was shown by forenoon relative humidity of air and plant canopy, soil moisture at 5 and 20cm depth ($p<0.01$).

4.8.2.1.4. Bulking to physiological maturity

In white polythene mulching treatment sunshine hours showed significant negative correlation ($p<0.05$). Black polythene mulch didn't show any significant correlation with weather variables and fourth phenophase of turmeric.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by sunshine hours and afternoon soil temperature at 5cm depth. High significant positive correlation ($p<0.01$) was shown by maximum and minimum temperature. In green leaf mulching treatment significant correlations ($p<0.05$) was shown by evaporation and afternoon soil temperature at 20cm depth. Maximum temperature, minimum temperature and forenoon soil temperature at 20cm depth showed high significant positive correlation.

Table 4.39. (a) Correlation between weather parameters and days to each phenophases

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.954**	0.954**	-0.926**	-0.812**	0.941**	-0.608*	-0.716**	0.942**	0.971**
	M2	0.968**	0.967**	-0.939**	-0.909**	0.941**	-0.892**	-0.722**	0.952**	0.969**
	M3	0.807**	0.676**	-0.862**	-0.878**	0.620*	-0.728**	-0.617*	0.780**	0.945**
	M4	0.595*	0.437	-0.735**	-0.699**	0.338	-0.352	-0.393	0.553*	0.916**
P2	M1	0.936**	0.902**	-0.895**	-0.570*	-0.787**	-0.811**	0.956**	-0.255	0.953**
	M2	0.829**	0.830**	-0.835**	-0.796**	-0.835**	-0.817**	0.782**	0.283	0.709**
	M3	0.935**	0.929**	-0.955**	-0.881**	-0.278	0.798**	0.974**	-0.521*	0.927**
	M4	0.808**	0.903**	-0.804**	-0.2	-0.602*	0.557*	0.962**	-0.899**	0.971**
P3	M1	0.634**	-0.938**	-0.41	-0.699**	0.101	-0.191	0.768**	0.804**	0.770**
	M2	0.514*	-0.938**	-0.306	-0.576*	0.088	-0.296	0.098	0.720**	0.667**
	M3	0.516*	-0.692**	-0.413	-0.571*	0.447	0.32	0.724**	0.720**	0.789**
	M4	0.486	-0.338	-0.649**	-0.413	0.860**	0.579*	0.745**	0.357	0.796**
P4	M1	-0.484	-0.285	0.26	0.308	-0.217	0.303	0.309	-0.523*	-0.221
	M2	0.079	-0.16	0.116	0.095	-0.137	0.108	0.1	-0.003	-0.108
	M3	0.651**	0.645**	-0.295	-0.313	0.26	-0.311	-0.329	0.585*	0.454
	M4	0.771**	0.802**	-0.281	-0.258	0.263	-0.269	-0.302	-0.005	0.557*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.39. (b) Correlation between weather parameters and days to each phenophases

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.931**	0.910**	0.929**	0.952**	-0.879**	-0.879**	-0.922**	-0.822**
	M2	0.961**	0.971**	0.935**	0.974**	-0.892**	-0.909**	-0.941**	-0.905**
	M3	0.830**	0.878**	0.821**	0.831**	-0.825**	-0.814**	-0.863**	-0.877**
	M4	0.659**	-0.308	0.609*	0.605*	-0.667**	-0.666**	-0.732**	-0.693**
P2	M1	0.916**	0.930**	0.708**	0.818**	-0.942**	-0.942**	0.928**	-0.059
	M2	0.825**	0.835**	0.747**	0.632**	-0.779**	-0.823**	0.778**	-0.653**
	M3	0.926**	0.968**	-0.037	0.908**	0.771**	0.692**	0.957**	0.2
	M4	0.844**	0.930**	-0.189	0.833**	0.681**	0.703**	0.961**	0.148
P3	M1	0.797**	-0.742**	0.099	0.413	-0.616*	-0.729**	-0.198	-0.715**
	M2	0.024	-0.790**	-0.278	0.252	-0.436	-0.488	-0.242	-0.606*
	M3	0.603*	-0.414	-0.203	0.495	-0.429	-0.549*	-0.393	-0.592*
	M4	0.566*	0.652**	0.076	0.542*	-0.835**	-0.776**	-0.653**	-0.364
P4	M1	-0.16	-0.279	-0.468	-0.285	0.275	0.274	0.247	0.256
	M2	0.275	-0.145	-0.011	0.139	0.081	0.102	0.125	0.113
	M3	0.069	0.446	0.588*	0.456	-0.271	-0.271	-0.294	-0.281
	M4	0.069	0.729**	0.443	0.552*	-0.254	-0.254	-0.273	-0.209

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3. Influence of weather parameters on yield and yield attributes

4.8.3.1. Correlation between weather parameters and length of primary rhizome

The correlation between weather parameters and length of primary rhizome at different phenophases are explained here (Table 4.40. (a) and (b)).

4.8.3.1.1. Planting to germination

During the time of planting to germination weather parameters had no correlation with length of primary rhizomes.

4.8.3.1.2. Germination to initiation of active tillering

In white polythene mulch during germination to initiation of active tillering afternoon soil temperature showed high significant positive correlation (at one percent level) on length of primary rhizome. Forenoon relative humidity, afternoon relative humidity, wind speed, rainfall, afternoon relative humidity of air and crop canopy showed high significant negative correlation (at one percent level).

4.8.3.1.3. Initiation of active tillering to bulking

In white polythene mulch during initiation of active tillering to bulking afternoon relative humidity, rainy days, soil moisture at 5cm, 20cm depth and afternoon relative humidity of air and plant canopy showed significant positive correlation (at five percent level) with length of primary rhizome. Forenoon relative humidity of air and plant canopy showed high significant positive correlation (at one percent level). Maximum temperature, daily evaporation, afternoon soil temperature at 5cm depth showed significant negative correlation (at five percent level). Wind speed and soil temperature at 20cm depth showed high significant negative correlation (at one percent level). No other mulching treatment showed significant correlation between weather parameters and length of primary rhizome.

4.8.3.1.4. Bulking to physiological maturity

In white polythene mulch maximum temperature, sunshine hours showed significant positive correlation (at five percent level) and forenoon soil temperature at 5cm depth and forenoon soil temperature at 20 cm depth showed high significant positive correlation (at one percent level).

Table 4.40. (a) Correlation between weather parameters and length of primary rhizome

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.206	0.293	-0.171	0.085	0.486	0.347	0.223	0.165	0.283
	M2	-0.255	-0.322	0.203	0.159	-0.4	0.14	-0.012	-0.228	-0.258
	M3	0.357	0.254	-0.404	-0.414	0.187	-0.324	-0.335	0.339	0.399
	M4	0.369	0.319	-0.424	-0.411	0.29	-0.247	-0.262	0.356	0.484
P2	M1	0.406	0.366	-0.602*	-0.808**	-0.720**	-0.627**	0.242	0.367	0.299
	M2	-0.435	-0.444	0.445	0.486	0.458	0.446	-0.354	-0.337	-0.479
	M3	0.4	0.412	-0.302	-0.177	0.192	0.364	0.343	0.049	0.411
	M4	0.207	0.305	-0.251	0.139	0.066	0.378	0.413	-0.402	0.411
P3	M1	-0.609*	0.169	0.754**	0.568*	-0.849**	0.486	0.536*	-0.459	-0.501*
	M2	0.456	-0.216	-0.485	-0.441	0.473	-0.467	-0.417	0.391	0.403
	M3	-0.17	0.355	0.103	0.222	-0.098	-0.151	-0.354	-0.312	-0.309
	M4	-0.368	0.375	0.405	0.377	-0.377	-0.129	-0.292	-0.369	-0.482
P4	M1	0.576*	-0.092	0.229	0.139	-0.302	0.123	0.131	.498*	-0.293
	M2	-0.189	0.147	-0.282	-0.237	0.317	-0.192	-0.215	0.07	0.295
	M3	-0.322	-0.331	0.369	0.391	-0.35	0.414	0.391	-0.415	-0.386
	M4	-0.145	-0.094	0.412	0.441	-0.404	0.449	0.413	-0.478	-0.301

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.40. (b) Correlation between weather parameters and length of primary rhizome

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.135	0.099	0.133	0.191	-0.164	-0.164	-0.15	0.069
	M2	-0.237	-0.262	-0.195	-0.276	0.271	0.305	0.206	0.154
	M3	0.356	0.405	0.366	0.418	-0.374	-0.38	-0.403	-0.414
	M4	0.383	-0.274	0.374	0.363	-0.379	-0.377	-0.417	-0.412
P2	M1	0.44	0.525*	0.731**	0.446	-0.164	-0.164	0.451	-0.745**
	M2	-0.464	-0.452	-0.484	-0.444	0.368	0.426	-0.349	0.474
	M3	0.416	0.371	0.284	0.252	0.224	0.167	0.274	0.325
	M4	0.221	0.256	-0.141	0.239	0.413	0.41	0.425	0.31
P3	M1	-0.47	-0.383	-0.598*	-0.648**	0.616*	0.521*	0.798**	0.552*
	M2	0.484	0.198	0.382	0.471	-0.45	-0.452	-0.489	-0.433
	M3	-0.17	0.32	0.218	-0.16	0.097	0.163	0.099	0.246
	M4	-0.406	-0.43	-0.028	-0.342	0.43	0.473	0.429	0.363
P4	M1	0.761**	-0.178	0.496	0.806**	0.201	0.204	0.251	0.236
	M2	-0.477	0.34	-0.028	-0.277	-0.235	-0.26	-0.301	-0.277
	M3	0.203	-0.355	-0.314	-0.093	0.244	0.244	0.37	0.374
	M4	0.415	0.339	-0.243	0.149	0.262	0.262	0.414	0.441

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.2. Correlation between weather parameters and width of primary rhizome

The correlation between weather parameters and width of primary rhizome at different phenophases are explained here (Table 4.41. (a) and (b)).

4.8.3.2.1. Planting to germination

In white polythene mulch wind speed showed significant positive correlation (at five percent level). In black polythene mulch maximum temperature, sunshine hours, and forenoon and afternoon soil temperature at 5cm showed significant positive correlation (at five percent level). Minimum temperature, daily pan evaporation, wind speed, forenoon and afternoon soil temperature at 20cm depth showed high significant positive correlation (at one percent level). Significant negative correlation ($p<0.05$) was showed by forenoon and afternoon relative humidity, rainfall, soil moisture at 5 and 20cm depth, forenoon and afternoon relative humidity of plant canopy.

In paddy straw mulch the significant correlation ($p<0.05$) was shown by maximum temperature, minimum temperature, sunshine hours, forenoon soil temperature at 20cm depth, afternoon soil temperature at 5 and 20 cm depth. High significant positive correlation ($p<0.05$) was shown by wind speed, daily evaporation and forenoon soil temperature at 5cm depth. In green leaf mulch forenoon soil temperature at 5cm showed significant positive correlation ($p<0.05$). Maximum temperature, minimum temperature, wind speed, sunshine hours, afternoon soil temperature at 5 and 20 cm depth showed a high significant positive correlation ($p<0.01$). Significant negative correlation was shown by forenoon relative humidity, soil moisture at 5, 20cm depth and forenoon relative humidity inside plant canopy ($p<0.05$). High significant negative correlation was shown by afternoon relative humidity, rainfall, rainy days, forenoon soil temperature at 20cm depth and afternoon relative humidity inside plant canopy ($p<0.01$).

4.8.3.2.2. Germination to initiation of active tillering

In white polythene mulch maximum temperature, forenoon soil temperature at 5cm, afternoon soil temperature at 20cm, forenoon relative humidity inside plant canopy showed significant positive correlation (at five percent level). High significant positive correlation ($p<0.01$) was shown by forenoon soil temperature at 20cm depth and afternoon soil temperature at 5cm depth. High significant negative correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity, wind speed, rainfall, afternoon relative humidity inside plant canopy. In black polythene mulch afternoon soil temperature at 20cm depth showed significant positive correlation (at five percent level). Maximum, minimum temperature, rainy days, daily pan evaporation, forenoon soil temperature at 5and 20 cm depth, afternoon soil temperature at 5cm depth, forenoon relative humidity of air and plant canopy showed high significant positive correlation (at one percent level). Significant negative correlation ($p<0.05$) was showed by afternoon relative humidity of air and crop canopy. High significant negative correlation ($p<0.01$) was showed by forenoon and afternoon relative humidity, wind speed, rainfall and soil moisture at 5 and 20cm depth.

In paddy straw mulch, significant positive correlation ($p<0.05$) was shown by minimum temperature, rainy days, evaporation, fore noon soil temperature at 5cm depth and fore noon relative humidity of plant canopy. A high significant positive correlation ($p<0.01$) was shown by maximum temperature, rainy fall, forenoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth, forenoon soil temperature at 20cm depth, afternoon soil temperature at 20cm depth, soil moisture at 5 and 20cm depth and forenoon relative humidity of plant canopy. Significant negative correlation ($p<0.05$) was shown by afternoon relative humidity and high significant negative correlation ($p<0.01$) was shown by forenoon relative humidity. In green leaf mulch minimum temperature, forenoon soil temperature at 5cm, afternoon soil temperature at 20cm, soil moisture at 5and 20cm showed significant positive correlation ($p<0.01$). Minimum temperature, rainy days, evaporation, forenoon soil temperature at 20 cm depth, forenoon relative humidity in plant canopy showed a high significant positive correlation ($p<0.01$). Significant negative correlation was shown by forenoon relative humidity. High significant negative correlation was shown by sunshine hours.

4.8.3.2.3. Active tillering to bulking

In white polythene mulch soil moisture at 20cm showed significant positive correlation ($p<0.05$). High significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity, rainfall, soil moisture at 5cm depth, forenoon and afternoon relative humidity in plant canopy. Significant negative correlation ($p<0.05$) was shown by sunshine hours, evaporation and forenoon soil temperature at 5cm depth. High significant negative correlation ($p<0.01$) was shown by maximum temperature, wind speed, after noon soil temperature at 5 and 20cm depth and. In black polythene mulch Minimum temperature showed significant positive correlation ($p<0.05$). Forenoon and afternoon relative humidity, rainfall, soil moisture at 5, 20cm depth, forenoon and afternoon relative humidity of plant canopy showed high significant positive correlation ($p<0.01$). Significant negative correlation ($p<0.05$) was showed by forenoon soil temperature at 5cm. High significant negative correlation ($p<0.01$) was showed by maximum temperature, wind speed, sunshine hours, daily evaporation and afternoon soil temperature at 20cm depth.

In paddy straw mulch minimum temperature showed significant positive correlation. High significant positive correlation was shown by forenoon and afternoon relative humidity, soil moisture at 5 and 20cm depth, forenoon and afternoon relative humidity of plant canopy. High significant negative correlation was shown by maximum temperature, wind speed, sunshine hours, evaporation, forenoon soil temperature at 5 and afternoon soil temperature at 20cm depth. In green leaf mulch minimum temperature and soil moisture at 5cm depth showed significant positive correlation. Forenoon and afternoon relative humidity, soil moisture at 20 cm depth, forenoon and afternoon relative humidity of plant canopy showed a high significant positive correlation at one percent level. Significant negative correlation was shown by evaporation. High significant negative correlation was shown by maximum temperature, sunshine hours, forenoon soil temperature at 5, 20cm and afternoon soil temperature at 20cm depth.

4.8.3.2.4. Bulking to physiological maturity

In white polythene mulch maximum temperature, forenoon and after noon soil temperature at 5cm showed significant positive correlation (at five percent level). High significant positive correlation (at one percent level) was showed by afternoon soil temperature at 20cm depth. In black polythene mulch afternoon relative humidity, rainfall, rainy days, forenoon soil temperature at 5cm depth, soil moisture at 5, 20cm depth showed significant positive correlation (at five percent level). High significant positive correlation (at one percent level) was shown by forenoon relative humidity, forenoon soil temperature at 5cm depth, forenoon and afternoon relative humidity in plant canopy. High significant negative correlation (at one percent level) was showed by wind speed, evaporation and forenoon soil temperature at 20cm.

In paddy straw mulch significant positive correlation (at five percent level) was shown by rainfall, rainy days, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm, soil moisture at 5, 20cm depth. High significant positive correlation (at one percent level) was shown by forenoon and afternoon relative humidity, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, forenoon and afternoon relative humidity inside plant canopy. Significant negative correlation (at five percent level) was shown by daily evaporation. High negative correlation (at one percent level) was shown by wind speed. In green leaf mulch forenoon and afternoon relative humidity, rainfall, rainy days, afternoon soil temperature at 20 cm depth, forenoon and afternoon relative humidity of plant canopy showed a significant positive correlation (at five percent level). High positive correlation (at one percent level) was shown by forenoon soil temperature at 5cm, soil moisture at 5 and 20cm. Significant negative correlation (at one percent level) was shown by wind speed.

Table 4.41. (a) Correlation between weather parameters and width of primary rhizome

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.284	0.416	-0.224	0.015	0.601*	0.271	0.149	0.248	0.354
	M2	0.615*	0.659**	-0.571*	-0.519*	0.709**	-0.501*	-0.305	0.585*	0.624**
	M3	0.618*	0.617*	-0.598*	-0.596*	0.629**	-0.587*	-0.46	0.616*	0.657**
	M4	0.661**	0.710**	-0.616*	-0.633**	0.724**	-0.641**	-.635**	0.677**	0.474
P2	M1	0.551*	0.421	-0.694**	-0.864**	-0.796**	-0.747**	0.389	0.416	0.448
	M2	0.720**	0.718**	-0.734**	-0.683**	-0.733**	-0.698**	0.701**	0.224	0.625**
	M3	0.638**	0.607*	-0.697**	-0.621*	-0.281	0.678**	0.614*	-0.27	0.614*
	M4	0.576*	0.649**	-0.568*	-0.119	-0.444	0.436	0.714**	-0.677**	0.717**
P3	M1	-0.708**	0.242	0.815**	0.660**	-0.850**	0.637**	0.484	-0.558*	-0.592*
	M2	-0.729**	0.582*	0.705**	0.730**	-0.639**	0.648**	0.441	-0.718**	-0.730**
	M3	-0.720**	0.601*	0.687**	0.723**	-0.670**	0.298	-0.038	-0.714**	-0.729**
	M4	-0.725**	0.588*	0.675**	0.718**	-0.364	0.361	0.177	-0.690**	-0.616*
P4	M1	0.575*	-0.096	0.329	0.231	-0.403	0.173	0.207	0.42	-0.405
	M2	-0.048	-0.475	0.635**	0.595*	-0.666**	0.560*	0.580*	-0.402	-0.635**
	M3	0.027	-0.056	0.640**	0.630**	-0.658**	0.620*	0.619*	-0.286	-0.498*
	M4	-0.023	-0.222	0.608*	0.574*	-0.630**	0.538*	0.591*	-0.252	-0.478

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.41. (b) Correlation between weather parameters and width of primary rhizome

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.217	0.168	0.21	0.285	-0.316	-0.316	-0.207	-0.002
	M2	0.600*	0.627**	0.559*	0.633**	-0.573*	-0.609*	-0.573*	-0.512*
	M3	0.639**	0.609*	0.618*	0.548*	-0.611*	-0.593*	-0.601*	-0.594*
	M4	0.619*	-0.720**	0.656**	0.638**	-0.597*	-0.595*	-0.606*	-0.641**
P2	M1	0.502*	0.636**	0.822**	0.608*	-0.316	-0.316	0.521*	-0.755**
	M2	0.711**	0.732**	0.630**	0.508*	-0.669**	-0.712**	0.691**	-0.555*
	M3	0.579*	0.639**	-0.05	0.719**	0.733**	0.714**	0.622*	0.238
	M4	0.604*	0.678**	-0.182	0.594*	0.523*	0.538*	0.709**	0.132
P3	M1	-0.555*	-0.382	-0.722**	-0.768**	0.645**	0.568*	0.859**	0.647**
	M2	-0.599*	0.033	-0.34	-0.641**	0.724**	0.735**	0.678**	0.730**
	M3	-0.686**	0.091	-0.308	-0.716**	0.678**	0.713**	0.685**	0.715**
	M4	-0.714**	-0.689**	-0.452	-0.675**	0.528*	0.630**	0.688**	0.709**
P4	M1	0.800**	-0.311	0.501*	0.863**	0.308	0.304	0.356	0.328
	M2	0.687**	-0.681**	-0.289	0.105	0.584*	0.614*	0.651**	0.631**
	M3	0.727**	-0.485	0.144	0.508*	0.547*	0.547*	0.641**	0.651**
	M4	0.714**	0.237	0.136	0.550*	0.677**	0.677**	0.611*	0.612*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.3. Correlation between weather parameters and number of mother rhizomes

The correlation between weather parameters and number of mother rhizome at different phenophases are explained here (Table 4.42. (a) and (b)).

4.8.3.3.1. Planting to germination

White polythene mulch showed high significant positive correlation ($P<0.01$) with forenoon and afternoon relative humidity, rainfall, rainy days, soil moisture at 5, 20cm depth, forenoon and afternoon relative humidity inside the plant canopy in white polythene mulch. Wind speed showed significant negative correlation ($P<0.05$). High significant negative correlation ($P<0.01$) was showed by maximum and minimum temperature, sunshine hours, daily pan evaporation, forenoon and afternoon soil temperature at 5 and 20 cm depth. Black polythene mulch does not showed any significant correlation with weather parameters.

Paddy straw mulch showed significant negative correlation ($P<0.05$) with minimum temperature and wind speed. Green leaves showed ($P<0.05$) significant negative correlation with daily pan evaporation.

4.8.3.3.2. Germination to initiation of active tillering

High significant positive correlation ($P<0.01$) with soil moisture at 5 and 20 cm depths were shown by white polythene mulch. High significant negative correlation ($P<0.01$) was showed by maximum temperature, minimum temperature, rainy days, evaporation, forenoon soil temperature at 5cm depth and forenoon relative humidity inside plant canopy. The black polythene mulched treatment didn’t show any correlation with weather components and number of mother rhizomes.

Paddy straw mulch showed significant correlation ($P<0.05$) with afternoon relative humidity, wind speed and sunshine hours. Significant negative correlation ($P<0.05$) was showed by afternoon soil temperature at 20cm depth and forenoon relative humidity inside plant canopy. In green leaves mulch significant negative correlation ($P<0.05$) was showed by soil moisture at 5cm depth.

4.8.3.3.3. Active tillering to bulking

Significant positive correlation ($P<0.05$) was shown by rainy days, sunshine hours, daily pan evaporation and forenoon soil temperature at 5cm depth. Minimum temperature, forenoon soil temperature at 20cm depth and soil moisture at 20cm depth showed significant negative correlation ($P<0.05$). Black polythene mulch didn't show any significant correlation with number of mother rhizomes and weather variables.

Paddy straw mulch showed significant correlations ($P<0.05$) with afternoon soil temperature at 20cm depth. Rainfall, afternoon relative humidity of air and plant canopy showed significant negative correlation ($P<0.05$). In green leaf mulch evaporation showed significant positive correlation ($P<0.05$) and soil moisture at 5 and 20cm depth showed negative correlation.

4.8.3.3.4. Bulking to physiological maturity

Afternoon soil temperature at 5cm depth showed significant positive correlation of five percent in white polythene mulch. One percent positive correlation was showed by wind speed, sunshine hours, evaporation and forenoon soil temperature at 20cm depth. Negative correlation of one percent level was showed by forenoon and after noon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5and 20cm depth. Black polythene mulch does not showed any correlation with weather variables and number of mother rhizomes.

In paddy straw mulch forenoon soil temperature at 5cm depth, soil moisture at 5 and 20 cm depth showed significant negative correlation ($P<0.05$). Green leaf mulch showed significant positive correlation ($P<0.05$) with sunshine hours.

Table 4.42. (a) Correlation between weather parameters and number of mother rhizomes

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	-0.669**	-0.630**	0.661**	0.706**	-0.517*	0.681**	0.702**	-0.681**	-0.640**
	M2	-0.085	-0.071	0.094	0.088	-0.064	0.092	0.08	-0.082	-0.091
	M3	-0.428	-0.534*	0.34	0.315	-0.573*	0.464	0.397	-0.451	-0.303
	M4	-0.339	-0.285	0.413	0.396	-0.261	0.182	0.199	-0.324	-0.513*
P2	M1	-0.522*	-0.596*	0.436	0.066	0.291	0.319	-0.621*	0.466	-0.588*
	M2	-0.058	-0.055	0.065	0.038	0.062	0.045	-0.083	0.03	-0.04
	M3	-0.339	-0.317	0.484	0.577*	0.503*	-0.264	-0.446	0.536*	-0.317
	M4	-0.127	-0.254	0.18	-0.273	-0.178	-0.482	-0.433	0.447	-0.422
P3	M1	0.417	-0.676**	-0.251	-0.47	0.029	-0.079	0.592*	0.553*	0.527*
	M2	0.059	-0.09	-0.051	-0.063	0.048	-0.024	0.023	0.074	0.082
	M3	0.493	-0.429	-0.472	-0.513*	0.398	-0.531*	-0.306	0.458	0.379
	M4	0.38	-0.342	-0.451	-0.365	0.493	0.25	0.405	0.344	0.543*
P4	M1	0.496	0.609*	-0.666**	-0.690**	0.638**	-0.668**	-0.685**	0.629**	0.638**
	M2	0.071	0.111	-0.08	-0.082	0.079	-0.097	-0.09	0.076	0.071
	M3	-0.039	0.052	-0.409	-0.366	0.436	-0.301	-0.367	0.125	0.343
	M4	0.088	-0.003	-0.396	-0.438	0.386	-0.451	-0.397	0.554*	0.245

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.42. (b) Correlation between weather parameters and number of mother rhizomes

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	-0.688**	-0.688**	-0.686**	-0.677**	0.643**	0.643**	0.668**	0.706**
	M2	-0.087	-0.09	-0.09	-0.082	0.05	0.052	0.093	0.087
	M3	-0.43	-0.335	-0.414	-0.3	0.4	0.388	0.342	0.314
	M4	-0.355	0.24	-0.345	-0.329	0.348	0.346	0.403	0.397
P2	M1	-0.564*	-0.489	-0.198	-0.377	0.643**	0.643**	-0.562*	-0.332
	M2	-0.048	-0.062	-0.021	0.01	0.055	0.056	-0.077	0.014
	M3	-0.308	-0.406	0.4	-0.508*	-0.422	-0.425	-0.519*	0.232
	M4	-0.147	-0.199	0.247	-0.167	-0.504*	-0.497	-0.441	-0.445
P3	M1	0.551*	-0.578*	0.011	0.244	-0.42	-0.506*	-0.089	-0.483
	M2	0.018	-0.069	-0.038	0.022	-0.075	-0.072	-0.037	-0.066
	M3	0.334	-0.111	0.275	0.498*	-0.43	-0.429	-0.49	-0.516*
	M4	0.428	0.468	0.039	0.379	-0.520*	-0.532*	-0.468	-0.342
P4	M1	-0.257	0.665**	0.524*	-0.053	-0.674**	-0.674**	-0.657**	-0.663**
	M2	-0.057	0.075	0.092	0.052	-0.076	-0.079	-0.078	-0.08
	M3	-0.501*	0.383	-0.253	-0.421	-0.526*	-0.526*	-0.408	-0.398
	M4	-0.425	-0.466	0.265	-0.174	-0.206	-0.206	-0.399	-0.438

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.4. Correlation between weather parameters and number of primary rhizomes

The correlation between weather parameters and number of primary rhizomes at different phenophases are explained here (Table 4.43. (a) and (b)).

4.8.3.4.1. Planting to germination

In the first phenophase white polythene mulch showed significant positive correlation (P<0.05) with forenoon relative humidity, soil moisture at 5, 20cm depths and forenoon relative humidity in plant canopy. Afternoon relative humidity, rainfall, rainy days and afternoon relative humidity inside plant canopy showed high significant positive correlation (P<0.01). Maximum temperature, minimum temperature, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depth showed significant negative correlation (P<0.05). No other mulching treatment showed significant correlation with weather parameters.

4.8.3.4.2. Germination to initiation of active tillering

White polythene mulch showed significant positive correlation (at five percent level) with soil moisture at 5 and 20cm depth. Black polythene mulch didn’t show any significant correlation with any weather elements.

The paddy straw mulch showed significant positive correlation (at five percent level) with forenoon relative humidity and significant negative correlation (at five percent level) was showed with afternoon soil temperature at 20cm depth, soil moisture at 5 and 20cm depth.

4.8.3.4.3. Active tillering to bulking

Significant positive correlation (at five percent level) in white polythene mulch was shown by rainy days. Minimum temperature and forenoon soil temperature at 20cm depth showed significant negative correlation (at five percent level). In black polythene mulch weather parameters does not showed any positive or negative correlation with number of primary rhizomes.

In case of paddy straw mulch maximum temperature, sunshine hours, daily pan evaporation and afternoon soil temperature at 20 cm depth showed positive correlation (at five percent level). Forenoon and afternoon relative humidity, soil moisture at 20cm depth, forenoon and afternoon relative humidity inside plant canopy showed significant negative correlation (at five percent level). In green leaves rainfall and rainy days showed significant positive correlation (at five percent level).

4.8.3.4.4. Bulking to physiological maturity

In white polythene mulch minimum temperature, wind speed, sunshine hours, daily pan evaporation, afternoon soil temperature at 20cm depth and soil moisture at 5 cm depth showed positive correlation (at five percent level). Forenoon and afternoon relative humidity, rainfall, rainy day, soil moisture at 5, 20 cm depth, forenoon and afternoon relative humidity in plant canopy showed significant negative correlation (at five percent level).

In paddy straw mulch forenoon soil temperature at 5cm showed significant negative correlation (at five percent level). Black polythene mulch and green leaf mulch doesn’t showed any significant correlation with weather parameters.

Table 4.43. (a) Correlation between weather parameters and number of primary rhizomes

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	-0.592*	-0.541*	0.591*	0.646**	-0.427	0.637**	0.650**	-0.605*	-0.562*
	M2	-0.305	-0.289	0.304	0.31	-0.253	0.306	0.29	-0.309	-0.3
	M3	-0.445	-0.468	0.415	0.409	-0.484	0.434	0.345	-0.449	-0.444
	M4	0.222	0.301	-0.117	-0.146	0.326	-0.361	-0.341	0.247	-0.093
P2	M1	-0.43	-0.519*	0.348	0	0.21	0.233	-0.531*	0.465	-0.497
	M2	-0.226	-0.216	0.217	0.136	0.201	0.204	-0.275	0.144	-0.062
	M3	-0.439	-0.415	0.505*	0.481	0.271	-0.449	-0.447	0.267	-0.42
	M4	0.371	0.299	-0.317	-0.412	-0.544*	-0.164	0.142	-0.084	0.16
P3	M1	0.33	-0.602*	-0.174	-0.382	-0.025	-0.012	0.572*	0.465	0.44
	M2	0.205	-0.307	-0.144	-0.222	0.074	-0.143	-0.02	0.26	0.243
	M3	0.524*	-0.435	-0.502*	-0.529*	0.477	-0.286	-0.046	0.510*	0.504*
	M4	-0.198	0.171	0.078	0.225	0.231	0.550*	0.535*	-0.234	0.048
P4	M1	0.496	0.559*	-0.583*	-0.613*	0.552*	-0.602*	-0.612*	0.598*	0.551*
	M2	0.218	0.224	-0.301	-0.308	0.292	-0.3	-0.307	0.307	0.297
	M3	-0.032	0.035	-0.455	-0.44	0.471	-0.421	-0.434	0.185	0.356
	M4	0.001	-0.242	0.13	0.061	-0.155	0.023	0.116	0.32	-0.191

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.43. (b) Correlation between weather parameters and number of primary rhizomes

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	-0.613*	-0.618*	-0.613*	-0.597*	0.555*	0.555*	0.599*	0.645**
	M2	-0.306	-0.3	-0.308	-0.302	0.286	0.281	0.304	0.311
	M3	-0.458	-0.421	-0.442	-0.377	0.435	0.422	0.417	0.407
	M4	0.179	-0.343	0.213	0.217	-0.172	-0.172	-0.121	-0.15
P2	M1	-0.484	-0.398	-0.12	-0.289	0.555*	0.555*	-0.479	-0.355
	M2	-0.189	-0.21	-0.097	-0.047	0.263	0.232	-0.281	0.022
	M3	-0.397	-0.453	0.115	-0.524*	-0.517*	-0.507*	-0.467	-0.09
	M4	0.371	0.365	0.158	0.346	-0.108	-0.088	0.135	-0.371
P3	M1	0.465	-0.559*	-0.052	0.162	-0.346	-0.428	-0.021	-0.394
	M2	0.06	-0.216	-0.038	0.13	-0.177	-0.194	-0.126	-0.23
	M3	0.473	-0.068	0.244	0.523*	-0.488	-0.508*	-0.504*	-0.523*
	M4	-0.144	-0.082	-0.273	-0.142	-0.116	-0.027	0.081	0.246
P4	M1	-0.183	0.579*	0.518*	0.012	-0.591*	-0.592*	-0.573*	-0.582*
	M2	-0.118	0.284	0.267	0.179	-0.308	-0.305	-0.296	-0.302
	M3	-0.529*	0.356	-0.143	-0.389	-0.424	-0.424	-0.455	-0.459
	M4	0.157	-0.31	0.317	0.223	0.358	0.358	0.129	0.087

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.5. Correlation between weather parameters and number of secondary rhizomes

The correlation between weather parameters and number of secondary rhizomes at different phenophases are explained here (Table 4.44. (a) and (b)).

4.8.3.5.1. Planting to germination

Number of secondary rhizome showed significant negative correlation (at five percent level) with rainfall in white polythene mulch.

Green leaf mulch showed significant positive correlation (at five percent level) with maximum and minimum temperature, wind speed, sunshine hours and afternoon soil temperature at 5cm depth. Rainfall, rainy days and forenoon soil temperature at 20cm depth showed negative correlation (at five percent level). Both black polythene and paddy straw mulch doesn't showed any significant correlation at any level.

4.8.3.5.2. Germination to initiation of active tillering

In white polythene mulch sunshine hours and afternoon soil temperature showed significant positive correlation ($p<0.05$) with number of secondary tillers. Afternoon relative humidity in air and inside plant canopy showed significant negative correlation ($p<0.01$) with number of secondary rhizomes. Sunshine hours, daily pan evaporation, afternoon soil temperature at 5 and 20 cm depth showed significant positive correlation ($p<0.05$) in black polythene mulch. Afternoon relative humidity in air and plant canopy showed significant negative correlation ($p<0.05$).

Paddy straw mulch didn't show any significant correlation with secondary rhizomes. Maximum temperature, minimum temperature, rainy days, daily pan evaporation, forenoon soil temperature at 5cm, afternoon soil temperature at 20cm depth and forenoon relative humidity inside plant canopy showed significant positive correlation ($p<0.05$) in green leaf mulch. Wind speed showed negative correlation ($p<0.05$) in green leaf mulch.

4.8.3.5.3. Active tillering to bulking

Significant positive correlation in white polythene mulch was shown by the forenoon relative humidity of air and inside plant canopy ($p<0.05$) with number of secondary rhizome. High significant positive correlation ($p<0.01$) was showed by rainy days and negative correlation was showed by wind speed. Significant negative correlation ($p<0.05$) was showed by forenoon soil temperature at 20cm depth and afternoon soil temperature at 5cm depth. In black polythene mulch, rainy days and forenoon relative humidity inside plant canopy showed positive correlation ($p<0.05$). Significant negative correlation ($p<0.05$) was shown by wind speed, forenoon and afternoon soil temperature at 5, 20 cm.

In paddy straw mulch significant positive ($p<0.05$) correlation was showed by afternoon relative humidity of air and plant canopy and significant negative correlation ($p<0.05$) was showed by maximum temperature and afternoon soil temperature at 20cm depth. Significant positive correlation ($p<0.05$) in green leaves mulch was shown by afternoon relative humidity of air and plant canopy shown. Significant negative correlation ($p<0.05$) was showed by maximum temperature, sunshine hours, forenoon soil temperature at 5cm and afternoon soil temperature.

4.8.3.5.4. Bulking to physiological maturity

In white polythene mulch significant positive correlation ($p<0.05$) was shown by forenoon soil temperature at 5cm depth. Maximum temperature, sunshine hour’s afternoon soil temperature at 5 and20cm depth showed high significant positive correlation ($p<0.05$). Black polythene mulch showed significant correlation ($p<0.05$) in maximum temperature and afternoon soil temperature at 20cm depth.

In paddy straw mulch the forenoon soil temperature at 5cm depth showed positive correlation ($p<0.05$). Forenoon soil temperature at 5cm depth, soil moisture at 5 and 20cm depth showed significant positive correlation ($p<0.05$) in green leaf mulching treatment.

Table 4.44. (a) Correlation between weather parameters and number of secondary rhizomes

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	-0.105	0	0.14	0.357	0.201	0.552*	0.464	-0.141	-0.034
	M2	-0.008	0.111	0.086	0.145	0.256	0.172	0.353	-0.045	-0.006
	M3	0.415	0.45	-0.378	-0.37	0.472	-0.411	-0.325	0.422	0.4
	M4	0.514*	0.581*	-0.44	-0.464	0.604*	-0.559*	-0.546*	0.535*	0.26
P2	M1	0.148	0.045	-0.321	-0.637**	-0.474	-0.406	-0.026	0.524*	0.034
	M2	0.334	0.359	-0.348	-0.503*	-0.383	-0.381	0.154	0.615*	0.554*
	M3	0.399	0.376	-0.476	-0.469	-0.296	0.403	0.419	-0.288	0.38
	M4	0.519*	0.538*	-0.491	-0.238	-0.511*	0.222	0.522*	-0.478	0.530*
P3	M1	-0.338	-0.14	0.513*	0.279	-0.664**	0.414	0.673**	-0.157	-0.199
	M2	-0.379	-0.067	0.481	0.34	-0.528*	0.485	0.572*	-0.227	-0.25
	M3	-0.499*	0.407	0.481	0.503*	-0.452	0.309	0.086	-0.477	-0.464
	M4	-0.553*	0.443	0.474	0.556*	-0.148	0.46	0.339	-0.539*	-0.38
P4	M1	0.683**	0.2	-0.076	-0.163	0.005	-0.183	-0.173	0.649**	0.008
	M2	0.521*	0.111	0.037	-0.032	-0.094	-0.102	-0.069	0.253	-0.067
	M3	0.047	-0.021	0.421	0.403	-0.439	0.379	0.398	-0.156	-0.327
	M4	0.001	-0.23	0.44	0.388	-0.465	0.349	0.422	-0.023	-0.377

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.44. (b) Correlation between weather parameters and number of secondary rhizomes

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	-0.169	-0.203	-0.172	-0.115	0.096	0.096	0.158	0.344
	M2	-0.035	0.001	-0.098	0.027	-0.067	-0.115	0.083	0.152
	M3	0.427	0.383	0.411	0.34	-0.403	-0.39	-0.38	-0.368
	M4	0.467	-0.608*	0.507*	0.496	-0.449	-0.448	-0.434	-0.471
P2	M1	0.122	0.244	0.531*	0.253	0.096	0.096	0.135	-0.748**
	M2	0.416	0.367	0.550*	0.572*	-0.214	-0.318	0.149	-0.610*
	M3	0.359	0.419	-0.153	0.497	0.483	0.476	0.432	0.041
	M4	0.538*	0.586*	-0.066	0.520*	0.3	0.319	0.515*	-0.06
P3	M1	-0.161	-0.565*	-0.523*	-0.456	0.313	0.206	0.621*	0.262
	M2	-0.586*	-0.528*	-0.592*	-0.504*	0.379	0.37	0.515*	0.319
	M3	-0.439	0.056	-0.251	-0.499*	0.465	0.479	0.485	0.497*
	M4	-0.523*	-0.482	-0.419	-0.503*	0.299	0.398	0.481	0.558*
P4	M1	0.507*	0.103	0.634**	0.642**	-0.099	-0.1	-0.053	-0.073
	M2	0.486	-0.136	0.367	0.586*	-0.028	0.005	0.07	0.03
	M3	0.503*	-0.333	0.165	0.386	0.412	0.412	0.421	0.423
	M4	0.526*	0.033	0.233	0.46	0.583*	0.583*	0.441	0.425

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.6. Correlation between weather parameters and weight of mother rhizomes

The correlation between weather parameters and weight of mother rhizomes at different phenophases are explained here (Table 4.45. (a) and (b)).

4.8.3.6.1. Planting to germination

In white polythene mulch rainfall showed significant ($p<0.05$) positive correlations. Black polythene mulch showed significant positive correlation ($p<0.05$) by maximum temperature, sunshine hours, forenoon and afternoon soil temperature at 5cm depth. High significant positive correlation ($p<0.01$) was showed by minimum temperature, evaporation, forenoon and afternoon soil temperature at 20 cm depth. Forenoon and afternoon relative humidity of air and plant canopy, rainfall, soil moisture at 5 and 20 cm depth showed significant negative correlation ($p<0.05$).

In paddy straw mulch maximum temperature, sunshine hours, evaporation, forenoon soil temperature at 5 and 20cm and afternoon soil temperature at 5cm depth showed significant positive correlation ($p<0.05$). Negative correlation of five percent level was shown by forenoon and afternoon relative humidity of air and plant canopy, soil moisture at 5cm depth. In green leaves mulch significant positive correlation ($p<0.05$) was shown by maximum temperature, sunshine hours and afternoon soil temperature at 5cm depth. Negative correlation ($p<0.05$) was shown by forenoon soil temperature at 20cm depth, afternoon relative humidity of air and plant canopy.

4.8.3.6.2. Germination to initiation of active tillering

In white polythene mulch afternoon soil temperature at 5cm showed significant positive correlation ($p<0.05$). Wind speed showed five percent level, afternoon relative humidity of air and plant canopy showed one percent level negative correlation. In black polythene mulch evaporation and afternoon soil temperature at 5cm depth showed significant positive correlation ($p<0.05$). High significant positive correlation ($p<0.01$) was shown by maximum temperature, minimum temperature, rainy days, forenoon soil temperature at 5 and 20cm depth and forenoon relative humidity inside the plant canopy. Significant negative correlation ($p<0.05$) was shown by afternoon relative humidity and soil moisture at 5cm depth. High significant negative correlation ($p<0.01$) was shown by forenoon relative humidity, wind speed, rainfall and soil moisture at 20cm depth.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by minimum and maximum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20cm depths and afternoon soil temperature at 20cm depth. High significant positive correlation was shown by rainfall, soil moisture at 5 and 20cm depth. Significant negative correlation ($p<0.05$) was shown by forenoon relative humidity. In green leaf mulching significant positive correlation (at five percent level) was shown by rainy days, evaporation, forenoon soil temperature at 20cm depth and forenoon relative humidity inside plant canopy. Significant negative correlation (at five percent level) was shown by sunshine hours. In green leaves significant positive correlation (at five percent level) was shown by rainy days, evaporation, forenoon soil temperature at 20cm depth and forenoon relative humidity in plant canopy and negative correlation was shown by sunshine hours.

4.8.3.6.3. Active tillering to bulking

White polythene mulch showed significant positive correlation ($p<0.05$) by forenoon relative humidity. Rainy days and forenoon relative humidity inside plant canopy showed high significant positive correlation ($p<0.01$). Significant negative correlation ($p<0.05$) was shown by forenoon soil temperature at 5, 20cm depths and afternoon soil temperature at 20cm depth. Wind speed showed high significant negative correlation. In black polythene mulch significant positive correlation ($p<0.05$) was shown by minimum temperature, rainfall and forenoon relative humidity inside plant canopy. High significant positive correlation ($p<0.01$) was shown by forenoon and afternoon relative humidity, soil moisture at 5, 20 cm depths and afternoon relative humidity inside plant canopy. Significant negative correlation ($p<0.05$) was shown by wind speed, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. High significant negative correlation ($p<0.01$) was shown by maximum temperature, sunshine hour and evaporation.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by soil moisture at 5cm depth, forenoon and afternoon relative humidity of air and inside plant canopy. High significant positive correlation ($p<0.01$) was shown by forenoon soil temperature at 20cm depth. Significant negative correlation ($p<0.05$) was shown by maximum temperature, wind speed, sunshine hours and afternoon soil temperature at 20cm depth. High significant negative correlation ($p<0.01$) was shown by evaporation and forenoon soil temperature at 5cm depth. In green leaves mulching, significant positive correlation ($p<0.05$) was shown by forenoon and afternoon relative humidity of air and plant canopy and soil moisture at 20cm depth. Significant negative correlation ($p<0.05$) was shown by maximum temperature, sunshine hours, evaporation, forenoon soil temperature at 5 and 20cm depth and afternoon soil temperature at 20cm depth.

4.8.3.6.4. Bulking to physiological maturity

In white polythene mulching treatment significant positive correlation ($p<0.05$) was shown by maximum temperature, sunshine hours and afternoon soil temperature at 5cm depth. High significant positive correlation was shown by afternoon soil temperature at 20cm depth. In black polythene mulch significant positive correlation ($p<0.05$) was shown by afternoon relative humidity, rainfall, rainy days, soil temperature at 5 and 20cm depth. High significant positive correlation was shown by forenoon relative humidity, forenoon soil temperature at 5cm depth, forenoon and afternoon relative humidity of air and inside plant canopy. Significant negative correlation was shown by minimum temperature and evaporation. High significant negative correlation was shown by wind speed and forenoon soil temperature at 20cm depth.

In paddy straw mulch significant positive correlation ($p<0.05$) was shown by forenoon relative humidity, rainfall, rainy days, forenoon soil temperature at 5cm depth, forenoon and afternoon soil temperature inside plant canopy. In green leaf mulching significant positive correlation ($p<0.05$) was shown by forenoon soil temperature at 5cm depth, soil moisture at 5 and 20 cm depth and relative humidity inside plant canopy. Green leaf mulch also showed significant negative correlation ($p<0.05$) was shown by wind speed.

Table 4.45. (a) Correlation between weather parameters and weight of mother rhizomes

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	-0.03	0.065	0.06	0.298	0.27	0.519*	0.417	-0.069	0.047
	M2	0.622*	0.636**	-0.599*	-0.544*	0.670**	-0.538*	-0.354	0.591*	0.641**
	M3	0.508*	0.476	-0.514*	-0.519*	0.48	-0.464	-0.347	0.499*	0.591*
	M4	0.512*	0.540*	-0.497	-0.505*	0.550*	-0.465	-0.464	0.522*	0.42
P2	M1	0.201	0.133	-0.396	-0.695**	-0.546*	-0.459	0.025	0.48	0.086
	M2	0.675**	0.669**	-0.698**	-0.621*	-0.695**	-0.636**	0.695**	0.156	0.588*
	M3	0.558*	0.530*	-0.578*	-0.471	-0.147	0.629**	0.499*	-0.114	0.539*
	M4	0.405	0.485	-0.409	0	-0.258	0.419	0.582*	-0.568*	0.580*
P3	M1	-0.41	-0.065	0.587*	0.355	-0.737**	0.417	0.659**	-0.233	-0.277
	M2	-0.686**	0.601*	0.661**	0.692**	-0.611*	0.567*	0.329	-0.696**	-0.722**
	M3	-0.608*	0.489	0.583*	0.602*	-0.590*	0.153	-0.125	-0.605*	-0.648**
	M4	-0.581*	0.459	0.567*	0.565*	-0.372	0.185	0.036	-0.536*	-0.541*
P4	M1	0.668**	0.118	-0.006	-0.094	-0.068	-0.105	-0.101	0.635**	-0.061
	M2	-0.133	-0.560*	0.630**	0.599*	-0.656**	0.597*	0.600*	-0.428	-0.615*
	M3	0.035	-0.025	0.538*	0.541*	-0.549*	0.551*	0.528*	-0.246	-0.404
	M4	-0.005	-0.123	0.486	0.471	-0.500*	0.449	0.474	-0.281	-0.357

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.45. (b) Correlation between weather parameters and weight of mother rhizomes

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	-0.098	-0.13	-0.099	-0.044	0.05	0.05	0.08	0.284
	M2	0.612*	0.642**	0.583*	0.632**	-0.529*	-0.563*	-0.601*	-0.537*
	M3	0.530*	0.527*	0.513*	0.471	-0.509*	-0.493	-0.516*	-0.518*
	M4	0.485	-0.542*	0.510*	0.493	-0.467	-0.465	-0.486	-0.511*
P2	M1	0.209	0.314	0.588*	0.286	0.05	0.05	0.22	-0.765**
	M2	0.655**	0.693**	0.553*	0.404	-0.621*	-0.663**	0.675**	-0.488
	M3	0.503*	0.537*	0.065	0.597*	0.643**	0.625**	0.486	0.321
	M4	0.43	0.497*	-0.206	0.426	0.48	0.489	0.579*	0.204
P3	M1	-0.242	-0.525*	-0.535*	-0.502*	0.407	0.297	0.678**	0.337
	M2	-0.527*	0.117	-0.225	-0.559*	0.714**	0.716**	0.618*	0.696**
	M3	-0.625**	0.043	-0.256	-0.602*	0.587*	0.623**	0.575*	0.590*
	M4	-0.583*	-0.576*	-0.341	-0.555*	0.485	0.549*	0.576*	0.552*
P4	M1	0.589*	0.047	0.608*	0.697**	-0.032	-0.03	0.017	0.001
	M2	0.660**	-0.663**	-0.365	0.024	0.579*	0.610*	0.641**	0.626**
	M3	0.611*	-0.378	0.089	0.416	0.403	0.403	0.539*	0.553*
	M4	0.578*	0.281	0.059	0.434	0.498*	0.498*	0.489	0.500*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.7. Correlation between weather parameters and weight of primary rhizomes

The correlation between weather parameters and weight of primary rhizomes at different phenophases are explained here (Table 4.46. (a) and (b)).

4.8.3.7.1. Planting to germination

In white polythene mulch no significant level correlation was shown by weather variables and weight of primary rhizomes. In black polythene mulch significant positive correlation (at five percent level) was shown by maximum temperature, minimum temperature, sunshine hours, forenoon soil temperature at 5cm and afternoon soil temperature at 5 and 20cm depths. High significant positive correlation (at one percent level) was shown by wind speed. Significant negative correlation (at five percent level) was shown by soil moisture at 20cm depths.

Weather variables and weight of primary rhizomes didn’t show any significant level correlation with paddy straw mulch. In green leaf mulching treatment significant positive correlation (at five percent level) was shown by maximum temperature, minimum temperature, wind speed, sunshine hours, forenoon soil temperature in 5cm depth and afternoon soil temperature in 5 and 20cm depths. significant negative correlation (at five percent level) was shown by forenoon and afternoon relative humidity of air and inside plant canopy, rainfall, rainy days, forenoon soil temperature in 20cm depth and soil moisture content in 5 and 20cm depths.

4.8.3.7.2. Germination to initiation of active tillering

In white polythene mulch significant positive correlation (at five percent level) was shown by sunshine hours and afternoon soil temperature in 20cm depth. High significance (at one percent level) was shown by afternoon soil temperature at 5cm depth. Significant negative correlation (at five percent level) was shown by forenoon relative humidity. High negative correlation (at one percent level) was shown by afternoon relative humidity of air and plant canopy, wind speed and rainfall. In black polythene mulch significant positive correlation (at five percent level) was shown by afternoon soil temperature at 20cm and forenoon relative humidity inside plant canopy. Significant positive correlation (at one percent level) was shown by maximum temperature, minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity inside plant canopy. Significant level negative correlation (at five percent level) was shown by soil moisture at 5cm depth and afternoon relative humidity inside plant canopy. Negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity, wind speed, rainfall and soil moisture at 20cm depths.

The paddy straw mulch showed no significant level correlation was shown by weather variables and weight of primary rhizomes. In green leaf mulching treatment significant positive correlation (at five percent level) was shown by maximum temperature, minimum temperature, rainy days, evaporation, forenoon soil temperature in 5 and 20cm depths and afternoon soil temperature in 5cm depth and forenoon relative humidity inside plant canopy. Significant negative correlation (at five percent level) was shown by forenoon relative humidity of air and sunshine hours.

4.8.3.7.3. Active tillering to bulking

In white polythene mulch significant positive correlation (at five percent level) was shown by rainy days. High significant correlation (at one percent level) was shown by forenoon relative humidity of air and plant canopy and rainfall. Significant negative correlation (at five percent level) was shown by maximum temperature and forenoon soil temperature in 20cm depth. High significant negative correlation (at one percent level) was shown by wind speed, afternoon soil temperature at 5 and 20cm depths. In black polythene mulch significant positive correlation (at five percent level) was shown by forenoon soil temperature at 5cm depth. High significant positive correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air and inside plant canopy, rainfall, soil moisture at 5 and 20cm depths.

Significant negative correlation (at five percent level) was shown by soil temperature at 5cm depth. Significant negative correlation (at one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation and soil temperature at 20cm depths.

The paddy straw mulch showed no significant level correlation was shown by weather variables and weight of primary rhizomes. In green leaf mulching treatment significant positive correlation (at five percent level) was shown by minimum temperature, forenoon and afternoon relative humidity of air and plant canopy. Significant negative correlation (at five percent level) was shown by maximum temperature, and sunshine hours, forenoon soil temperature in 5 and 20cm depths.

4.8.3.7.4. Bulking to physiological maturity

In white polythene mulch significant positive correlation (at five percent level) was shown by sunshine hours. High significant correlation (at one percent level) was shown by maximum temperature, forenoon soil temperature at 5cm depth and afternoon soil temperature at 5 and 20cm depths. In black polythene mulch significant positive correlation (at five percent level) was shown by forenoon sand afternoon relative humidity of air and plant canopy, wind speed, soil moisture at 20cm depth. High significant positive correlation (at one percent level) was shown by forenoon soil temperature at 5cm depth. Significant negative correlation (at five percent level) was shown by evaporation and soil temperature at 20cm depth.

The paddy straw mulch showed no significant level correlation with weather variables and weight of primary rhizomes. In green leaf mulching treatment significant positive correlation (at five percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 20cm depths, soil moisture in five and 20cm depths. Significant negative correlation (at five percent level) was shown by evaporation.

Table 4.46. (a) Correlation between weather parameters and weight of primary rhizome

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.076	0.244	-0.005	0.213	0.444	0.428	0.328	0.042	0.144
	M2	0.528*	0.579*	-0.483	-0.423	0.648**	-0.407	-0.203	0.494	0.541*
	M3	0.405	0.434	-0.372	-0.364	0.452	-0.399	-0.318	0.41	0.392
	M4	0.600*	0.618*	-0.563*	-0.576*	0.609*	-0.596*	-0.594*	0.608*	0.436
P2	M1	0.421	0.205	-0.538*	-0.795**	-0.670**	-0.651**	0.243	0.581*	0.308
	M2	0.672**	0.674**	-0.692**	-0.671**	-0.698**	-0.656**	0.633**	0.301	0.645**
	M3	0.392	0.37	-0.46	-0.45	-0.273	0.394	0.408	-0.27	0.374
	M4	0.563*	0.601*	-0.561*	-0.23	-0.426	0.253	0.573*	-0.506*	0.587*
P3	M1	-0.563*	0.031	0.689**	0.496	-0.752**	0.664**	0.607*	-0.38	-0.414
	M2	-0.691**	0.492	0.694**	0.686**	-0.656**	0.628**	0.456	-0.657**	-0.679**
	M3	-0.479	0.396	0.46	0.484	-0.433	0.287	0.069	-0.462	-0.45
	M4	-0.574*	0.560*	0.504*	0.610*	-0.191	0.365	0.174	-0.610*	-0.472
P4	M1	0.694**	0.131	0.135	0.032	-0.212	-0.046	-0.002	0.542*	-0.222
	M2	0.039	-0.422	0.550*	0.504*	-0.587*	0.474	0.49	-0.299	-0.550*
	M3	0.035	-0.03	0.411	0.394	-0.427	0.373	0.389	-0.16	-0.322
	M4	-0.16	-0.327	0.563*	0.531*	-0.577*	0.504*	0.552*	-0.222	-0.501*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.46. (b) Correlation between weather parameters and weight of primary rhizome

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.011	-0.043	0.003	0.086	-0.173	-0.173	0.01	0.197
	M2	0.512*	0.544*	0.468	0.548*	-0.485	-0.526*	-0.485	-0.416
	M3	0.416	0.376	0.401	0.336	-0.394	-0.381	-0.374	-0.363
	M4	0.576*	-0.607*	0.597*	0.590*	-0.565*	-0.564*	-0.560*	-0.580*
P2	M1	0.296	0.483	0.739**	0.539*	-0.173	-0.173	0.321	-0.805**
	M2	0.678**	0.693**	0.630**	0.517*	-0.600*	-0.660**	0.618*	-0.584*
	M3	0.354	0.409	-0.134	0.479	0.466	0.459	0.432	0.051
	M4	0.578*	0.608*	-0.002	0.574*	0.342	0.356	0.578*	-0.009
P3	M1	-0.366	-0.550*	-0.744**	-0.698**	0.45	0.364	0.788**	0.482
	M2	-0.614*	-0.054	-0.373	-0.626**	0.703**	0.706**	0.671**	0.683**
	M3	-0.422	0.062	-0.231	-0.478	0.445	0.46	0.463	0.479
	M4	-0.567*	-0.534*	-0.275	-0.494	0.353	0.482	0.533*	0.615*
P4	M1	0.656**	-0.146	0.643**	0.801**	0.118	0.109	0.166	0.128
	M2	0.688**	-0.606*	-0.199	0.186	0.491	0.525*	0.569*	0.545*
	M3	0.483	-0.327	0.146	0.363	0.397	0.397	0.411	0.413
	M4	0.588*	0.078	0.025	0.359	0.609*	0.609*	0.564*	0.554*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.8. Correlation between weather parameters and weight of secondary rhizomes

The correlation between weather parameters and weight of secondary rhizomes at different phenophases are explained here (Table 4.47. (a) and (b)).

4.8.3.8.1. Planting to germination

Paddy straw mulch showed significant positive correlation (at 5 percent level) with minimum temperature, wind speed, evaporation and forenoon soil temperature at 5cm depth. All other mulching treatments didn't show any correlation with weight of secondary rhizomes and weather variables.

4.8.3.8.2. Germination to initiation of active tillering

In white polythene mulching afternoon soil temperature at 5cm depth showed high significant positive correlation (at one percent level). Rainfall showed high significant negative correlation (at one percent level). Afternoon relative humidity of air and plant canopy and rainfall showed significant negative correlation (at five percent level). In black polythene mulch sunshine hours, forenoon and afternoon soil temperature at 5 and 20cm depths showed significant positive correlation (at five percent level). Evaporation showed high significant positive correlation (at one percent level) in black polythene mulch. Afternoon relative humidity of air and wind speed showed significant negative correlation (at five percent level). Afternoon relative humidity inside plant canopy showed high significant negative correlation (at one percent level).

In paddy straw mulching treatment significant positive correlation (at five percent level) was shown by afternoon relative humidity, rainfall and forenoon relative humidity of plant canopy. Afternoon soil temperature at 20cm depth, soil moisture at 5 and 20 cm depths showed high significant positive correlation (at one percent level). Forenoon relative humidity showed significant negative correlation (at five percent level) with weight of secondary rhizomes. Green leaf mulching treatment didn't show any significant correlation with weight of secondary rhizomes and weather variables.

4.8.3.8.3. Active tillering to bulking

In white polythene mulching treatment forenoon relative humidity of air and plant canopy showed significant positive correlation at one percent level. Rainfall showed high significant negative correlation at one percent level. Rainfall and rainy days showed significant negative correlation at five percent level. High significant negative correlation of one percent level was shown by wind speed. Significant negative correlation of five percent was shown by maximum temperature, afternoon soil temperature at 5 and 20cm depths. In black polythene mulch forenoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5 and 20cm depths showed significant positive correlation at five percent level. Afternoon maximum temperature, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth showed significant negative correlation at five percent level. Wind speed showed high significant negative correlation at one percent level.

In paddy straw mulching treatment one percent level high significant positive correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, soil moisture at 5 and 20cm depths. Sunshine hours showed significant five percent negative correlations. Forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, evaporation, wind speed and maximum temperature showed high significant correlation at one percent level. Green leaf mulching treatment didn’t show any significant correlation with weight of secondary rhizomes and weather variables.

4.8.3.8.4. Bulking to physiological maturity

The black polythene mulch showed significant positive correlation of five percent level with forenoon soil temperature at 5cm depth.

Paddy straw mulching showed significant correlation with forenoon relative humidity, wind speed, afternoon soil temperature at 20cm depth and forenoon and afternoon relative humidity of plant canopy. High significant correlation was shown by forenoon soil temperature at 5cm depth. Both white polythene mulch and green leaf mulch didn’t show any significant correlation with any weather parameters.

Table 4.47. (a) Correlation between weather parameters and weight of secondary rhizomes

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.067	0.188	-0.02	0.209	0.384	0.431	0.328	0.031	0.138
	M2	0.181	0.262	-0.127	-0.053	0.39	-0.039	0.169	0.136	0.201
	M3	0.474	0.514*	-0.438	-0.434	0.564*	-0.447	-0.292	0.477	0.525*
	M4	0.331	0.367	-0.322	-0.328	0.392	-0.281	-0.277	0.341	0.279
P2	M1	0.333	0.212	-0.492	-0.746**	-0.623**	-0.565*	0.163	0.486	0.223
	M2	0.455	0.472	-0.487	-0.578*	-0.517*	-0.468	0.34	0.541*	0.645**
	M3	0.492	0.448	-0.597*	-0.559*	-0.373	0.582*	0.474	-0.26	0.459
	M4	0.218	0.299	-0.22	0.121	-0.127	0.407	0.444	-0.465	0.432
P3	M1	-0.508*	0.028	0.653**	0.453	-0.752**	0.524*	0.595*	-0.339	-0.377
	M2	-0.504*	0.136	0.589*	0.474	-0.640**	0.522*	0.499*	-0.389	-0.435
	M3	-0.709**	0.453	0.714**	0.676**	-0.711**	0.363	0.109	-0.619*	-0.657**
	M4	-0.448	0.275	0.465	0.4	-0.376	0.066	-0.012	-0.359	-0.435
P4	M1	-0.448	0.275	0.465	0.4	-0.376	0.066	-0.012	-0.359	-0.435
	M2	0.348	-0.16	0.212	0.15	-0.266	0.122	0.133	0.083	-0.219
	M3	0.231	0.149	0.499*	0.481	-0.527*	0.469	0.467	-0.077	-0.319
	M4	0.114	0.035	0.309	0.302	-0.321	0.284	0.297	-0.207	-0.173

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.47. (b) Correlation between weather parameters and weight of secondary rhizomes

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.001	-0.04	-0.003	0.063	-0.091	-0.091	-0.002	0.194
	M2	0.16	0.204	0.106	0.208	-0.164	-0.217	-0.13	-0.044
	M3	0.500*	0.452	0.471	0.373	-0.46	-0.436	-0.442	-0.432
	M4	0.302	-0.383	0.329	0.308	-0.283	-0.281	-0.31	-0.335
P2	M1	0.291	0.423	0.668**	0.419	-0.091	-0.091	0.308	-0.760**
	M2	0.513*	0.499*	0.585*	0.530*	-0.324	-0.433	0.317	-0.634**
	M3	0.413	0.497	-0.157	0.653**	0.707**	0.719**	0.511*	0.151
	M4	0.244	0.32	-0.281	0.238	0.436	0.441	0.434	0.262
P3	M1	-0.339	-0.492	-0.623*	-0.604*	0.462	0.368	0.735**	0.437
	M2	-0.617*	-0.362	-0.485	-0.538*	0.551*	0.532*	0.590*	0.46
	M3	-0.700**	-0.111	-0.474	-0.709**	0.715**	0.719**	0.710**	0.649**
	M4	-0.45	-0.456	-0.328	-0.463	0.435	0.442	0.457	0.381
P4	M1	-0.45	-0.456	-0.328	-0.463	0.435	0.442	0.457	0.381
	M2	0.615*	-0.298	0.147	0.461	0.136	0.178	0.24	0.205
	M3	0.696**	-0.313	0.328	0.619*	0.433	0.433	0.499*	0.512*
	M4	0.428	0.317	0.107	0.396	0.319	0.319	0.312	0.33

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.9. Correlation between weather parameters and fresh yield

The correlation between weather parameters and fresh yield at different phenophases are explained here (Table 4.48. (a) and (b)).

4.8.3.9.1. Planting to germination

The correlation between fresh yield and weather variables show that in white polythene mulch significant positive correlation (at five percent level) was shown by maximum temperature, sunshine hours, forenoon and afternoon soil temperature at 5 and 20cm depths. High significant positive correlation (at one percent level) was shown by minimum temperature, wind speed and evaporation. Significant negative correlation (five percent level) was shown by forenoon relative humidity of air and inside plant canopy, soil moisture at 5 and 20cm depths. In black polythene mulch high significant positive correlation (at one percent level) was shown by maximum and minimum temperature, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. High significant negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, soil moisture of 5 and 20cm depths.

In paddy straw mulch significant positive correlation (at five percent level) was shown by evaporation, forenoon soil temperature at 20cm depths and afternoon soil temperature at 5cm depths. High significant positive correlation (at one percent level) was shown by maximum and minimum temperature, wind speed, sunshine hours and forenoon soil temperature at 5cm depth. Significant positive correlation (at five percent level) was shown by forenoon relative humidity of air and plant canopy, afternoon relative humidity of air, rainy days, soil moisture at 5 and 20cm depths. High significant negative correlation (at one percent level) was shown by rainfall. In green leaf mulch significant positive correlation (at five percent level) was shown by evaporation. High significant positive correlation (at one percent level) was shown by maximum and minimum temperature, sunshine hours, forenoon soil temperature at 5cm depth and afternoon soil temperature at 5 and 20cm depths. High significant negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5 and 20cm depths and forenoon soil temperature at 20cm depth.

4.8.3.9.2. Germination to initiation of active tillering

In white polythene mulch the significant positive correlation (at five percent level) was shown by rainy days. High significant positive correlation (at one percent level) was shown by maximum and minimum temperature, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity inside plant canopy. Significant negative correlation (at five percent level) was shown by soil moisture at 5 and 20cm depths. High significant negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air, wind speed and rainfall. In black polythene mulch significant positive correlation (at five percent level) was shown by evaporation and afternoon soil temperature at 20cm depth. High significant positive correlation (at one percent level) was shown by maximum and minimum temperature, rainy days, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 5cm depth and forenoon relative humidity inside plant canopy. Significant negative correlation (at five percent level) was shown by afternoon relative humidity inside plant canopy. High significant negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity of air, wind speed and sunshine hours.

In paddy straw mulch the significant positive correlation (at five percent level) was shown by maximum temperature, minimum temperature, rainfall, evaporation, forenoon soil temperature at 20cm depth. The high significant positive correlation (at one percent level) was shown by rainy days, afternoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth and forenoon relative humidity of plant canopy. High significant negative correlation (at one percent level) was shown by forenoon and afternoon relative humidity, wind speed and sunshine hours. In green leaf mulch rainfall showed positive correlation (at five percent level). Maximum temperature, minimum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20 cm depth, afternoon soil temperature at 20 cm depth, soil moisture at 5and 20cm depth, forenoon relative humidity of plant canopy showed a high significant positive correlation (at one percent level). Significant negative correlation (at five percent level) was shown by wind speed. Significant negative correlation (at one percent level) was shown by forenoon relative humidity and sunshine hours.

4.8.3.9.3. Active tillering to bulking

In white polythene mulch minimum temperature showed significant positive correlation (at five percent leavel). High significant positive correlation (at one percent level) was shown by forenoon and afternoon relative humidity, soil moisture at 5 and 20cm depth, forenoon and afternoon relative humidity in plant canopy. Significant negative correlation (at five percent level) was shown by afternoon soil temperature at 5cm depth. High significant negative correlation (at one percent level) was shown by maximum temperature, wind speed, sunshine hours, daily evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. In black polythene mulch Minimum temperature, forenoon and afternoon relative humidity, rainfall, soil moisture at 5, 20cm depth, forenoon and afternoon relative humidity of plant canopy showed significant positive correlation (at one percent level). The significant negative correlation (at five percent level) was shown by wind speed and soil temperature at 5cm. High significant negative correlation (at one percent level) was showed by maximum temperature, sunshine hours, daily evaporation and afternoon soil temperature at 5cm depth.

In paddy straw mulch high significant positive correlation (at one percent level) was shown by minimum temperature, forenoon and afternoon relative humidity, rainy days, soil moisture at 5 and 20cm depth, forenoon and afternoon relative humidity of plant canopy. Significant negative correlation (at five percent level) was shown by soil temperature at 5cm. High significant negative correlation (at one percent level) was shown by maximum temperature, wind speed, sunshine hours, evaporation and soil temeperature at 20cm depth. In green leaf mulch minimum temperature, forenoon and afternoon relative humidity, soil moisture at 5 and 20 cm depth, forenoon and afternoon relative humidity of plant canopy showed a significant positive correlation (at one percent level). Significant negative correlation (at five percent level) was shown by soil temperature at 5cm depth. High significant negative correlation (at one percent level) was shown by maximum temperature, sunshine hour’s evaporation, forenoon soil temperature at 5 and 20cm depth and afternoon soil temperature at 20cm depth.

4.8.3.9.4. Bulking to physiological maturity

In white polythene mulch forenoon and afternoon relative humidity of air, rainfall, rainy days, soil moisture at 5, 20cm depth and forenoon and afternoon relative humidity inside plant canopy showed significant positive correlation (at five percent leavel). High significant positive correlation (at one percent level) was showed by forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. Significant negative correlation (at five percent level) was showed by soil temperature at 20cm depth. High significant negative correlation (at one percent level) was shown by wind speed and evaporation. In black polythene mulch forenoon and afternoon relative humidity, rainfall, rainy days, forenoon soil temperature at 5cm depth, soil moisture at 5, 20cm depth, forenoon and afternoon relative humidity of plant canopy showed high significant positive correlation (at one percent level). High significant negative correlation (at one percent level) was showed by wind speed, evaporation and forenoon soil temperature at 20cm.

In paddy straw mulch significant positive correlation was shown by forenoon and afternoon relative humidity, rainy days, forenoon and afternoon relative humidity inside plant canopy. The high significant positive correlation was shown by forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth. Significant negative correlation was shown by morning soil temperature at 20cm depth. High significant negative correlation was shown by wind speed. In green leaf mulch forenoon and afternoon relative humidity, rainfall, rainy days, forenoon soil temperature at 20 cm depth, afternoon soil temperature at 20 cm depth, soil moisture at 5and 20cm depth, forenoon and afternoon relative humidity of plant canopy showed a high significant positive correlation. Significant negative correlation was shown by evaporation. High significant negative correlation was shown by wind speed.

Table 4.48. (a) Correlation between weather parameters and fresh yield

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.588*	0.643**	-0.552*	-0.351	0.748**	-0.102	-0.225	0.559*	0.640**
	M2	0.768**	0.818**	-0.708**	-0.678**	0.837**	-0.648**	-0.469	0.750**	0.758**
	M3	0.633**	0.761**	-0.527*	-0.498*	0.821**	-0.661**	-0.532*	0.659**	0.520*
	M4	0.830**	0.892**	-0.777**	-0.797**	0.914**	-0.796**	-0.789**	0.850**	0.605*
P2	M1	0.679**	0.687**	-0.802**	-0.763**	-0.820**	-0.754**	0.593*	0.047	0.624**
	M2	0.826**	0.819**	-0.816**	-0.726**	-0.801**	-0.806**	0.818**	0.1	0.580*
	M3	0.546*	0.506*	-0.739**	-0.824**	-0.674**	0.500*	0.653**	-0.666**	0.510*
	M4	0.708**	0.810**	-0.701**	-0.114	-0.536*	0.583*	0.912**	-0.874**	0.913**
P3	M1	-0.797**	0.559*	0.826**	0.792**	-0.776**	0.484	0.12	-0.745**	-0.766**
	M2	-0.808**	0.729**	0.731**	0.822**	-0.591*	0.728**	0.481	-0.833**	-0.810**
	M3	-0.791**	0.626**	0.770**	0.799**	-0.689**	0.699**	0.365	-0.719**	-0.650**
	M4	-0.926**	0.735**	0.872**	0.909**	-0.495	0.428	0.199	-0.868**	-0.798**
P4	M1	0.215	-0.45	0.607*	0.541*	-0.656**	0.513*	0.532*	0.064	-0.648**
	M2	-0.161	-0.49	0.792**	0.758**	-0.812**	0.687**	0.728**	-0.588*	-0.804**
	M3	0.127	0	0.622*	0.570*	-0.662**	0.497	0.567*	-0.163	-0.486
	M4	-0.007	-0.251	0.765**	0.724**	-0.792**	0.680**	0.743**	-0.335	-0.588*

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.48. (b) Correlation between weather parameters and fresh yield

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.536*	0.504*	0.534*	0.580*	-0.536*	-0.536*	-0.538*	-0.365
	M2	0.752**	0.763**	0.709**	0.787**	-0.773**	-0.797**	-0.712**	-0.674**
	M3	0.645**	0.527*	0.617*	0.46	-0.599*	-0.576*	-0.530*	-0.496
	M4	0.776**	-0.907**	0.824**	0.798**	-0.747**	-0.745**	-0.763**	-0.808**
P2	M1	0.734**	0.765**	0.774**	0.628**	-0.536*	-0.536*	0.742**	-0.466
	M2	0.794**	0.811**	0.663**	0.550*	-0.827**	-0.829**	0.826**	-0.519*
	M3	0.483	0.618*	-0.483	0.785**	0.714**	0.721**	0.744**	-0.189
	M4	0.747**	0.846**	-0.264	0.734**	0.690**	0.709**	0.905**	0.205
P3	M1	-0.753**	0.006	-0.542*	-0.727**	0.804**	0.771**	0.767**	0.785**
	M2	-0.596*	0.15	-0.348	-0.711**	0.740**	0.775**	0.711**	0.826**
	M3	-0.618*	0.078	-0.469	-0.795**	0.725**	0.725**	0.787**	0.792**
	M4	-0.914**	-0.886**	-0.584*	-0.871**	0.696**	0.816**	0.886**	0.895**
P4	M1	0.835**	-0.562*	0.127	0.753**	0.588*	0.590*	0.622*	0.612*
	M2	0.671**	-0.825**	-0.404	-0.011	0.761**	0.778**	0.805**	0.789**
	M3	0.794**	-0.525*	0.391	0.679**	0.722**	0.722**	0.621*	0.616*
	M4	0.910**	0.336	0.175	0.711**	0.845**	0.845**	0.769**	0.774**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.8.3.10. Correlation between weather parameters and dry yield

The correlation between weather parameters and dry yield at different phenophases are explained here (Table 4.49. (a) and (b)).

4.8.3.10.1. Planting to germination

The correlation between dry yield and weather variables show that in white polythene mulch five percent level significant positive correlation was shown by sunshine hours, forenoon soil temperature at 5 and 20cm depths, afternoon soil temperature at 5cm depths. One percent positive correlation was shown by maximum temperature, minimum temperature, wind speed, afternoon soil temperature at 20cm depth and evaporation. Five percent level significant negative correlation was shown by forenoon relative humidity of air and inside plant canopy and soil moisture at 5cm depth. In black polythene mulch the one percent significant positive correlation was shown by maximum and minimum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. One percent negative correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, soil moisture of 5 and 20cm depths.

In paddy straw mulch the five percent level significant positive correlation was shown by evaporation, forenoon soil temperature at 20cm depths and afternoon soil temperature at 20cm depth. One percent level significant positive correlation was shown by maximum and minimum temperature, wind speed, sunshine hours and forenoon and afternoon soil temperature at 5cm depth. Five percent level significant negative correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, rainy days. One percent level significant negative correlation was shown by rainfall, soil moisture at 5 and 20cm depths. In green leaf mulch one percent level significant positive correlation was shown by maximum and minimum temperature, wind speed, sunshine hours, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths. One percent level significant negative correlation was shown by forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, soil moisture at 5 and 20cm depths.

4.8.3.10.2. Germination to initiation of active tillering

In white polythene mulch the significant one percent level positive correlation was shown by maximum and minimum temperature, rainy days, evaporation, forenoon and afternoon soil temperature at 5 and 20cm depths and forenoon relative humidity inside plant canopy. Five percent level negative correlation was shown by soil moisture at 5 and 20cm depths. One percent level significant negative correlation was shown by forenoon and afternoon relative humidity of air, wind speed and rainfall. In black polythene mulch five percent level significant positive correlation was shown by evaporation and afternoon soil temperature at 20cm depth. One percent level significant positive correlation was shown by maximum and minimum temperature, rainy days, forenoon soil temperature at 5 and 20cm depths and afternoon soil temperature at 5cm depth. Five percent level significant negative correlation was shown by afternoon relative humidity inside plant canopy. One percent level significant negative correlation was shown by forenoon and afternoon relative humidity of air, forenoon relative humidity of plant canopy, wind speed, rainfall, soil moisture at 5 and 20cm depths.

In paddy straw mulch the five percent level significant positive correlation was shown by maximum temperature, minimum temperature, rainfall, evaporation, forenoon soil temperature at 5cm depth. The one percent significant positive correlation was shown by rainy days, forenoon and afternoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth and forenoon relative humidity of plant canopy. One percent level negative correlation was shown by forenoon and afternoon relative humidity, wind speed and sunshine hours. In green leaf mulch rainfall showed positive correlation at five percent level. Maximum temperature, minimum temperature, rainy days, evaporation, forenoon soil temperature at 5 and 20 cm depth, afternoon soil temperature at 20 cm depth, soil moisture at 5and 20cm depth and forenoon relative humidity of plant canopy showed a significant positive correlation at one percent level. Five percent significant negative correlation was shown by wind speed. One percent significant negative correlation was shown by forenoon relative humidity and sunshine hours.

4.8.3.10.3. Active tillering to bulking

In white polythene mulch minimum temperature and rainfall showed significant positive correlation at five percent level. One percent level significant positive correlation was shown by soil moisture at 5 and 20cm depth, forenoon and afternoon relative humidity of air and plant canopy. Five percent level significant negative correlation was shown by afternoon soil temperature at 5cm depth. One percent level significant negative correlation was shown by maximum temperature, wind speed, sunshine hours, daily evaporation, forenoon soil temperature at 5cm depth and afternoon soil temperature at 20cm depth. In black polythene mulch minimum temperature, forenoon and afternoon relative humidity of air and plant canopy, rainfall, soil moisture at 5, 20cm depth showed significant positive correlation at one percent level. The five percent level significant negative correlation was showed by wind speed and forenoon soil temperature at 5cm. One percent significant negative correlation was showed by maximum temperature, sunshine hours, daily evaporation and afternoon soil temperature at 20cm depth.

In paddy straw mulch one percent significant positive correlation was shown by minimum temperature, forenoon and afternoon relative humidity of air and plant canopy, rainfall, soil moisture at 5 and 20cm depth. Five percent level negative correlation was shown by forenoon soil temperature at 5cm. One percent level negative correlation was shown by maximum temperature, wind speed, sunshine hours, evaporation and soil temperature at 20cm depth. In green leaf mulch minimum temperature, forenoon and afternoon relative humidity of air and plant canopy, soil moisture at 5 and 20 cm depth showed a significant positive correlation at one percent level. Five percent significant negative correlation was shown by afternoon soil temperature at 5cm depth. One percent level significant negative correlation was shown by maximum temperature, sunshine hour’s, evaporation, forenoon soil temperature at 5 and 20cm depth and afternoon soil temperature at 20cm depth.

4.8.3.10.4. Bulking to physiological maturity

In white polythene mulch afternoon relative humidity of air, rainfall and rainy days showed significant positive correlation at five percent level. Forenoon relative humidity of air and plant canopy, afternoon relative humidity of plant canopy, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, soil moisture at 5 and 20cm depth showed significant positive correlation at one percent level. Five percent level significant negative correlation was showed by forenoon soil temperature at 20cm depth. One percent level significant negative correlation was shown by wind speed and evaporation. In black polythene mulch sunshine hours showed significant positive correlation of five percent level. Forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 5cm depth, soil moisture at 5, 20cm depth showed significant positive correlation at one percent level. One percent significant negative correlation was showed by wind speed, evaporation and forenoon soil temperature at 20cm.

In paddy straw mulch the five percent level significant positive correlation was shown by afternoon relative humidity of air, rainfall and rainy days. The one percent level significant positive correlation was shown by forenoon relative humidity of air and plant canopy, afternoon relative humidity of plant canopy, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20cm depth, soil moisture at 5cm and 20cm depth. Five percent level significant negative correlation was shown by evaporation and morning soil temperature at 20cm depth. One percent level negative correlation was shown by wind speed. In green leaf mulch forenoon and afternoon relative humidity of air and plant canopy, rainfall, rainy days, forenoon soil temperature at 5cm depth, afternoon soil temperature at 20 cm depth, soil moisture at 5 and 20cm depth showed a significant positive correlation at one percent level. One percent significant negative correlation was shown by wind speed and evaporation.

Table 4.49. (a) Correlation between weather parameters and dry yield

Growth stage	Mulches	TMAX	TMIN	RH1	RH2	WS	RF	RD	BSS	EVP
P1	M1	0.631**	0.694**	-0.589*	-0.393	0.792**	-0.145	-0.269	0.604*	0.680**
	M2	0.760**	0.809**	-0.701**	-0.672**	0.827**	-0.642**	-0.466	0.743**	0.749**
	M3	0.684**	0.802**	-0.581*	-0.552*	0.851**	-0.711**	-0.588*	0.709**	0.565*
	M4	0.857**	0.911**	-0.808**	-0.828**	0.926**	-0.820**	-0.814**	0.875**	0.639**
P2	M1	0.730**	0.722**	-0.838**	-0.777**	-0.847**	-0.791**	0.648**	0.039	0.678**
	M2	0.816**	0.809**	-0.806**	-0.716**	-0.791**	-0.796**	0.808**	0.096	0.571*
	M3	0.596*	0.559*	-0.778**	-0.853**	-0.656**	0.534*	0.703**	-0.678**	0.563*
	M4	0.735**	0.836**	-0.731**	-0.134	-0.541*	0.577*	0.926**	-0.879**	0.929**
P3	M1	-0.834**	0.601*	0.848**	0.830**	-0.777**	0.518*	0.086	-0.787**	-0.806**
	M2	-0.798**	0.722**	0.721**	0.811**	-0.582*	0.719**	0.475	-0.823**	-0.800**
	M3	-0.805**	0.678**	0.772**	0.823**	-0.687**	0.690**	0.328	-0.756**	-0.680**
	M4	-0.935**	0.768**	0.877**	0.928**	-0.489	0.433	0.187	-0.892**	-0.812**
P4	M1	0.195	-0.475	0.654**	0.588*	-0.702**	0.550*	0.574*	0.023	-0.696**
	M2	-0.161	-0.484	0.783**	0.750**	-0.803**	0.680**	0.720**	-0.583*	-0.795**
	M3	0.07	-0.06	0.672**	0.621*	-0.709**	0.548*	0.619*	-0.226	-0.544*
	M4	-0.047	-0.287	0.797**	0.757**	-0.823**	0.714**	0.776**	-0.363	-0.625**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch
P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity
TMAX- Maximum temperature, TMIN- Minimum temperature, RH I- Forenoon relative humidity, RH II- Afternoon relative humidity, WS- Wind speed, BSS- Bright sunshine hours, RF- Rainfall, RD- Rainy days and EVP- Evaporation

Table 4.49. (b) Correlation between weather parameters and dry yield

Growth stage	Mulches	STM5	STM20	STA5	STA20	SM5	SM20	RHMP	RHAP
P1	M1	0.581*	0.546*	0.577*	0.626**	-0.593*	-0.593*	-0.576*	-0.408
	M2	0.744**	0.755**	0.701**	0.778**	-0.766**	-0.789**	-0.704**	-0.667**
	M3	0.694**	0.580*	0.668**	0.517*	-0.651**	-0.630**	-0.584*	-0.550*
	M4	0.807**	-0.919**	0.852**	0.828**	-0.780**	-0.777**	-0.795**	-0.838**
P2	M1	0.769**	0.808**	0.801**	0.677**	-0.593*	-0.593*	0.779**	-0.455
	M2	0.784**	0.801**	0.654**	0.542*	-0.818**	-0.819**	0.816**	-0.510*
	M3	0.538*	0.668**	-0.459	0.815**	0.731**	0.730**	0.786**	-0.166
	M4	0.772**	0.865**	-0.238	0.761**	0.689**	0.708**	0.922**	0.195
P3	M1	-0.793**	0.029	-0.568*	-0.762**	0.827**	0.801**	0.783**	0.824**
	M2	-0.587*	0.15	-0.342	-0.701**	0.729**	0.765**	0.701**	0.816**
	M3	-0.622*	0.138	-0.427	-0.808**	0.725**	0.734**	0.790**	0.822**
	M4	-0.925**	-0.897**	-0.560*	-0.870**	0.697**	0.829**	0.896**	0.916**
P4	M1	0.853**	-0.616*	0.108	0.767**	0.636**	0.637**	0.670**	0.657**
	M2	0.661**	-0.815**	-0.4	-0.013	0.753**	0.770**	0.796**	0.780**
	M3	0.814**	-0.582*	0.343	0.656**	0.765**	0.765**	0.671**	0.664**
	M4	0.927**	0.327	0.14	0.693**	0.865**	0.865**	0.801**	0.805**

M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

P1 – Planting to germination, P2 – Germination to initiation of active tillering, P3 – Initiation of active tillering to bulking and P4 – Bulking to physiological maturity

STM5- Forenoon soil temperature at 5cm depth, STM20- Forenoon soil temperature at 20cm depth, STA5- Afternoon soil temperature at 5cm depth, STA20- Afternoon soil temperature at 20cm depth, SM5- Soil moisture at 5cm depth, SM20- Soil moisture at 20cm depth, RHMP- Forenoon relative humidity inside plant canopy, RHAP – Afternoon relative humidity inside plant canopy

4.9. PRINCIPAL COMPONENT ANALYSIS

4.9.1. Crop weather models using principal component analysis for predicting turmeric yield under different mulching treatments during different phenophases

For the process of fitting a model for predicting turmeric yield under different mulching treatments, principal component analysis was carried out to determine the best suited components whose contribution was more towards the dependent variable. The principal component analysis was carried out for turmeric by using weather variables experienced during four phenophases of growth stage. Weather variables such as maximum temperature, minimum temperature, forenoon and afternoon relative humidity, rainfall, rainy days, wind speed, bright sunshine hours, evaporation, soil temperature at 5 and 20 cm depths of soil during forenoon and afternoon and soil moisture at 5 and 20cm depths were used along with the yield data of turmeric from 2020 to 2021. By using scree plot method the principal components were retained and the components of each mulching treatments in each phenophase are given below.

4.9.1.1. Crop weather model using principal component analysis in white polythene mulch (M1)

In white polythene mulch during its first phenophase planting to germination it was observed that, a cumulative proportion of 97.74 percent was obtained for the first two components (component 1 and component 2) (Table 4.50 (a)). Component 1 explained 90.99 percent variation with an eigen value of 13.64 and component 2 explained 6.74 percent variance with 1.01 eigen value. The proportion of variance was explained by scree plot (Fig 4.1 (a)). From component 3 proportion of variance was very less. Hence for the yield prediction of white polythene mulch of first phenophase, only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.51 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.1

(a). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (a) and Fig 4.5 (a)).

Table 4.50. (a) Important components obtained after PCA analysis of first phenophase of white polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	13.64	90.99	90.99
2	1.01	6.74	97.74

Regression equation fitted was given below

$$\mathbf{Y=-8392.58-367.103X1+276.087X2}$$

In second phenophase germination to initiation of active tillering, 94.03 percent of cumulative proportion was obtained in the first two components (Table 4.50 (b)). The component 1 explained 76.61 percent variation with an eigen value of 11.49 and component 2 explained 17.41 percent variation with an eigen value of 2.61. The proportion of variance was explained by a scree plot (Fig 4.1 (b)). Proportion of variance in Component 3 was very little. So for the yield prediction of second phenophase only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.51 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.1 (b) The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (a) and Fig 4.5 (a)).

Table 4.50. (b) Important components obtained after PCA analysis of second phenophase of white polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	11.49	76.61	76.61
2	2.61	17.41	94.03

Regression equation fitted was given below

Y=120478-151.29X1+440.821X2****

The third phenopase initiation of active tillering to bulking showed a cumulative variance percent of 95.63percent from both component 1 and component 2 (Table 4.50 (c)). The component 1 explained 71.98 percent variance with an eigen value of 10.79 and component 2 explained 23.64 percent variance with an eigen value of 3.54. The proportion of variance was explained by a scree plot (Fig 4.1 (c)). Component proportion of variance of 3 was very little. So for the yield prediction of third phenophase, only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.51 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.1 (c). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (a) and Fig 4.5 (a)).

Table 4.50. (c) Important components obtained after PCA analysis of third phenophase of white polythene mulch

Components	Eigenvalue	Variance percent	Cumulative variance percent
1	10.79	71.98	71.98
2	3.54	23.64	95.63

Regression equation fitted was given below

Y=15283.45-242.295X1-126.852X2**

The cumulative variance percent of 95.02 percent was shown by both component 1 and component 2 in fourth phenopase bulking to physiological maturity (Table 4.50 (d)). The component 1 explained 74.17 percent variance with an eigen value of 11.12 and component 2 explained 20.85 percent variance with an eigen value of 3.12. The proportion of variance was explained in a scree plot (Fig 4.1 (d)). Component proportion of variance of 3 was very little. So for the yield prediction of fourth phenophase, only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.51 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.1 (d). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (a) and Fig 4.5 (a)).

Table 4.50. (d) Important components obtained after PCA analysis of fourth phenophase of white polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	11.12	74.17	74.17
2	3.12	20.85	95.02

Regression equation fitted was given below

Y=-22875.6+100.403X1*-1242.66X2**

Table 4.51. Loading values of different weather variables in forming principal components of white polythene mulch

Weather parameters	P1M1		P2M1		P3M1		P4M1	
	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2
Maximum temperature P1	-0.27	0.04	-0.29	-0.06	0.30	-0.002	0.17	-0.44
Minimum temperature P1	-0.26	0.29	-0.22	-0.32	-0.23	-0.33	0.26	-0.06
Forenoon relative humidity P1	0.26	0.08	0.29	0.01	-0.29	0.09	-0.29	-0.12
After noon relative humidity P1	0.26	0.30	0.23	-0.31	-0.30	-0.06	-0.30	-0.05
Wind speed P1	-0.23	0.50	0.27	-0.23	0.28	-0.12	0.29	0.17
Rainfall P1	0.23	0.51	0.28	-0.17	-0.21	0.33	-0.29	-0.01
Rainy days P1	0.24	0.41	-0.28	-0.16	0.01	0.48	-0.30	-0.03
Sunshine hours P1	-0.27	0.01	-0.05	0.61	0.29	0.12	0.21	-0.39
Evaporation P1	-0.27	0.10	-0.28	-0.11	0.30	0.11	0.28	0.17
Forenoon soil temperature at 5cm depths P1	-0.27	-0.03	-0.25	-0.30	0.30	0.04	-0.17	-0.46
Forenoon soil temperature at 20cm depths P1	-0.27	-0.11	-0.29	-0.02	-0.01	-0.52	0.29	0.09
Afternoon soil temperature at 5cm depths P1	-0.27	-0.06	-0.27	0.23	0.21	-0.36	0.19	-0.42
Afternoon soil temperature at 20cm depths P1	-0.27	0.06	-0.23	0.29	0.28	-0.19	0.16	-0.39
Soil moisture at 5cm depth P1	0.25	-0.24	0.27	0.19	-0.28	-0.11	-0.29	-0.09
Soil moisture at 20cm depth P1	0.25	-0.24	0.27	0.19	-0.28	-0.17	-0.29	-0.09

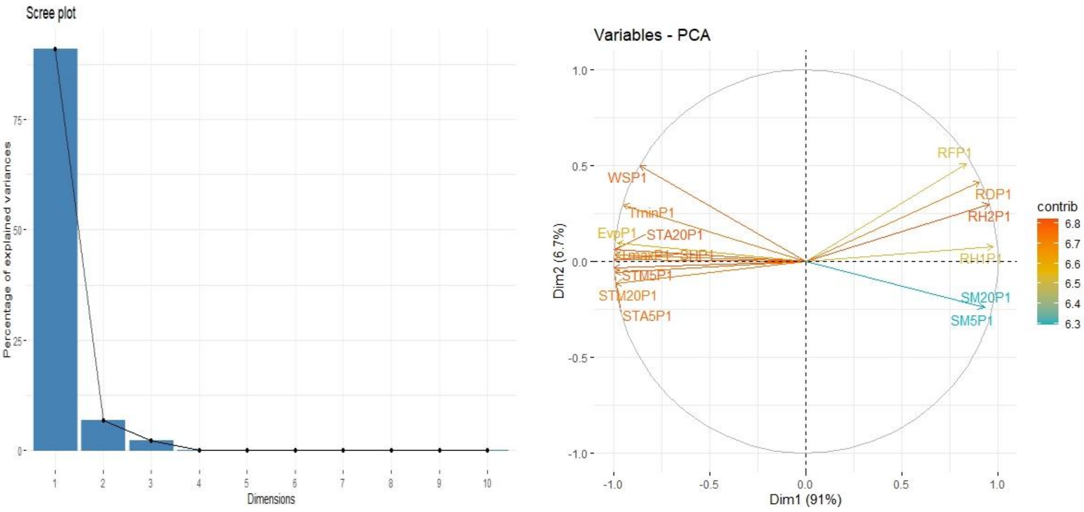


Fig 4.1. (a) Scree plot and variable factor map obtained after PCA analysis of first phenophase in white polythene mulch

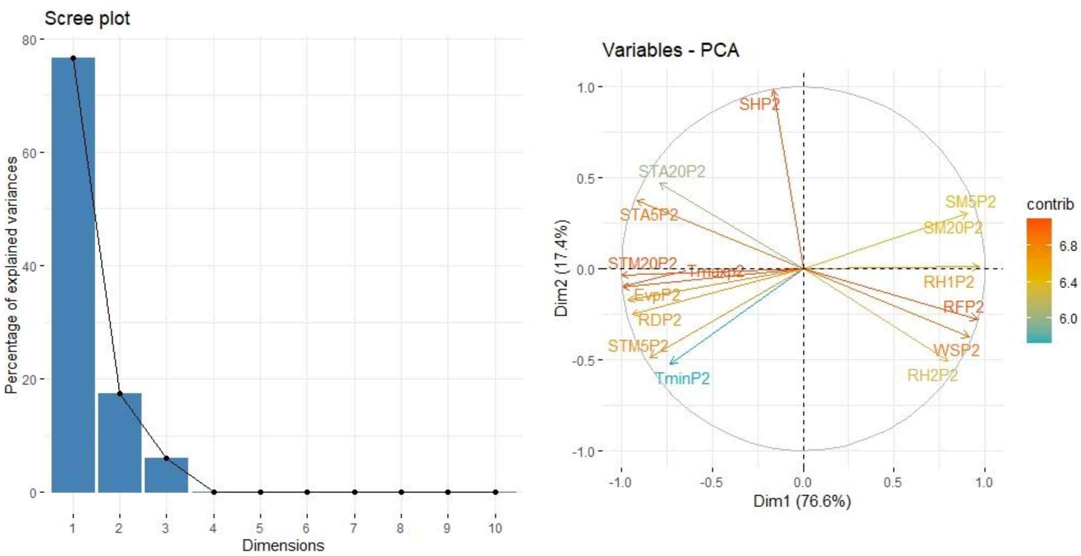


Fig 4.1. (b) Scree plot and variable factor map obtained after PCA analysis of second phenophase in white polythene mulch

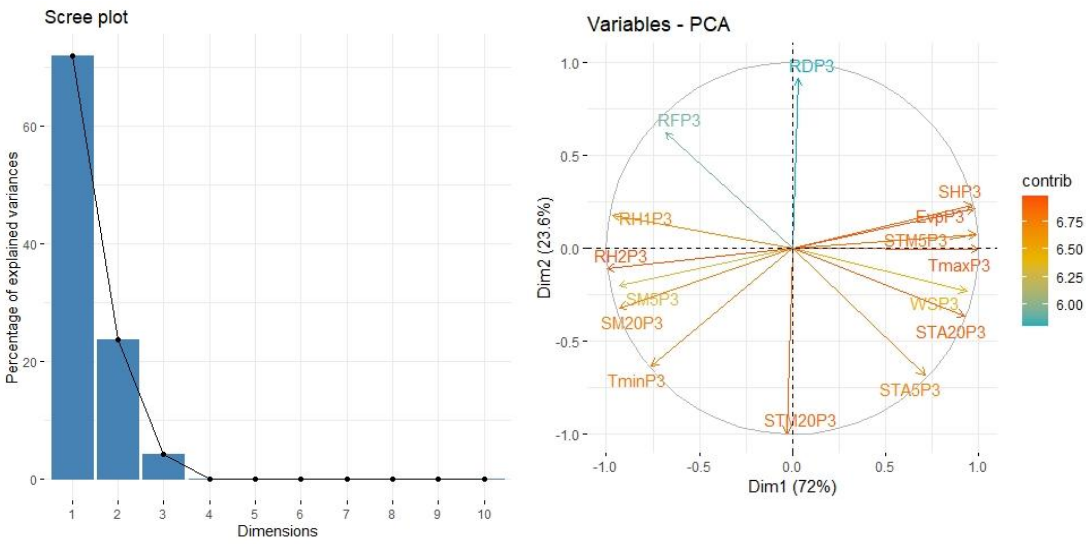


Fig 4.1. (c) Scree plot and variable factor map obtained after PCA analysis of third phenophase in white polythene mulch

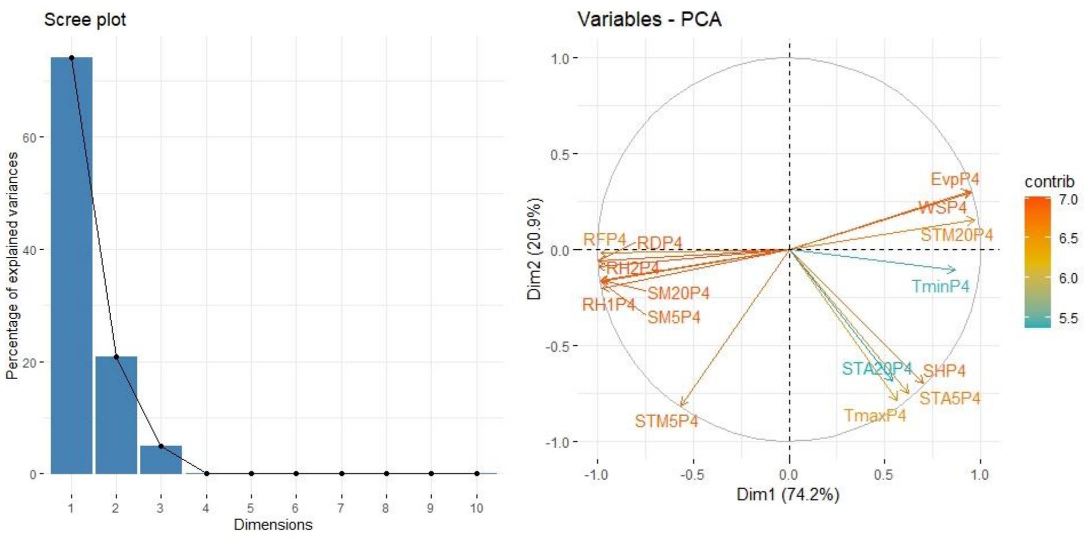


Fig 4.1. (d) Scree plot and variable factor map obtained after PCA analysis of fourth phenophase in white polythene mulch

4.9.1.2. Crop weather model using principal component analysis in black polythene mulch (M2)

In black polythene mulch in the first phenophase planting to germination it was observed that, a cumulative proportion of 98.73 percent was obtained for the first two components (Table 4.52. (a)). Component 1 explained 93.37 percent variance with an eigen value of 14 and component 2 explained 5.36 percent variance with an eigen value of 0.80. The proportion of variance was explained by a scree plot (Fig 4.2. (a)). So for the yield prediction of first phenophase, only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.53 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.2. (a). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58. (b) and Fig 4.5. (b)).

Table 4.52. (a) Important components obtained after PCA analysis of first phenophase of black polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	14.00	93.37	93.37
2	0.80	5.36	98.73

Regression equation fitted was given below

$$\mathbf{Y=-30467.1-559.304X1^{**}-699.355X2^{*}}$$

In second phenophase germination to initiation of active tillering, 97.55 percent of cumulative proportion was obtained in the first two components (Table 4.52. (b)). The component 1 explained 84.49 percent variance with an eigen value of 12.67 and component 2 explained 13.06 percent with an eigen value of 1.95. The proportion of variance was explained by a scree plot (Fig 4.2. (b)). Variance percent of other components of variance were very little. So for the yield prediction of second phenophase only two components were used in fitting the regression equation. The loading values of different obtained weather variables are given in the Table 4.53 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.2. (b). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58. (b) and Fig 4.5. (b)).

Table 4.52 (b) Important components obtained after PCA analysis of second phenophase of black polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	12.67	84.49	84.49
2	1.95	13.06	97.55

Regression equation fitted was given below

$$\mathbf{Y=67839.6+1.313X1^{**}-803.638X2^{**}}$$

The third phenopase initiation of active tillering to bulking showed a cumulative variance percent of 97.62 percent from both component 1 and component 2 (Table 4.52 (c)). The component 1 explained 75.03 percent variance with an eigen value of 11.25 and component 2 explained 22.58 percent variance with an eigen value of 3.38. The proportion of variance was explained by a scree plot (Fig 4.2 (c)). The yield prediction of third phenophase took only 2 components because other components were less significant. The loading values of different obtained weather variables are given in the Table 4.53 and the importance of different weather parameters in forming the two components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.2 (c). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (b) and Fig 4.5 (b)).

Table 4.52 (c) Important components obtained after PCA analysis of third phenophase of black polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	11.25	75.03	75.03
2	3.38	22.58	97.62

Regression equation fitted was given below

Y=9465.506-107.985X1-294.967X2***

The cumulative variance percent of 96.37 was shown by both component 1 and component 2 in fourth phenopase bulking to physiological maturity (Table 4.52 (d)). The component 1 explained variance percent of 77.46 with an eigen value of 11.61 and component 2 explained a variance percent of 18.90 with an eigen value of 2.83. The proportion of variance was explained by a scree plot (Fig 4.2 (d)). Both component 1 and 2 were taken for yield prediction. The loading values of different obtained weather variables are given in the Table 4.53 and the important weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.2 (d). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (b) and Fig 4.5 (b)).

Table 4.52 (d) Important components obtained after PCA analysis of fourth phenophase of black polythene mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	11.61	77.46	77.46
2	2.83	18.90	96.37

Regression equation fitted was given below

Y=-13872.7-56.631X1-1000.16X2****

Table 4.53. Loading values of different weather variables in forming principal components of black polythene mulch

Weather parameters	P1M2		P2M2		P3M2		P4M2	
	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2
Maximum temperature P1	-0.27	-0.01	-0.28	-0.11	0.30	0.05	0.16	-0.50
Minimum temperature P1	-0.26	-0.23	-0.27	-0.14	-0.17	-0.43	0.26	-0.13
Forenoon relative humidity P1	0.26	-0.15	0.28	0.08	-0.30	-0.0002	-0.29	-0.11
After noon relative humidity P1	0.26	-0.21	0.28	-0.14	-0.29	-0.13	-0.29	-0.04
Wind speed P1	-0.24	-0.49	0.28	0.05	0.29	-0.03	0.28	0.16
Rainfall P1	0.26	-0.29	0.28	0.04	-0.29	0.09	-0.29	0.03
Rainy days P1	0.23	-0.54	-0.25	-0.30	-0.24	0.31	-0.29	-0.01
Sunshine hours P1	-0.27	0.03	-0.08	0.68	0.26	0.23	0.27	-0.18
Evaporation P1	-0.26	0.03	-0.24	0.30	0.27	0.23	0.28	0.14
Forenoon soil temperature at 5cm depths P1	-0.27	0.04	-0.28	-0.07	0.25	-0.29	-0.14	-0.45
Forenoon soil temperature at 20cm depths P1	-0.27	0.03	-0.28	-0.001	0.04	-0.54	0.26	0.25
Afternoon soil temperature at 5cm depths P1	-0.26	0.16	-0.26	0.26	0.20	-0.40	0.26	-0.27
Afternoon soil temperature at 20cm depths P1	-0.26	-0.08	-0.21	0.37	0.28	-0.14	0.12	-0.54
Soil moisture at 5cm depth P1	0.25	0.30	0.26	0.25	-0.28	-0.13	-0.29	-0.07
Soil moisture at 20cm depth P1	0.25	0.37	0.27	0.14	-0.29	-0.11	-0.29	-0.08

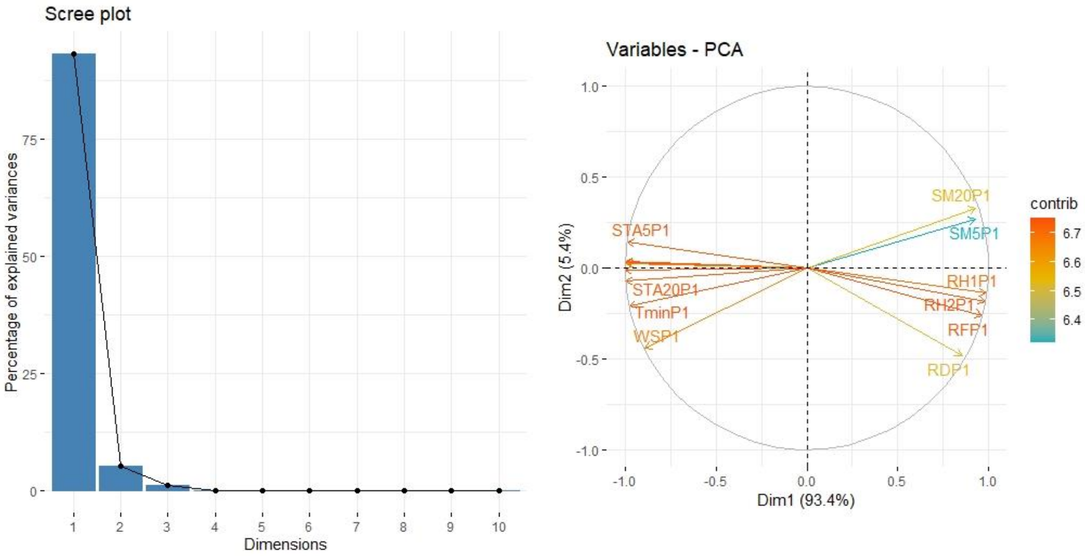


Fig 4.2 (a) Scree plot and variable factor map obtained after PCA analysis of first phenophase in black polythene mulch

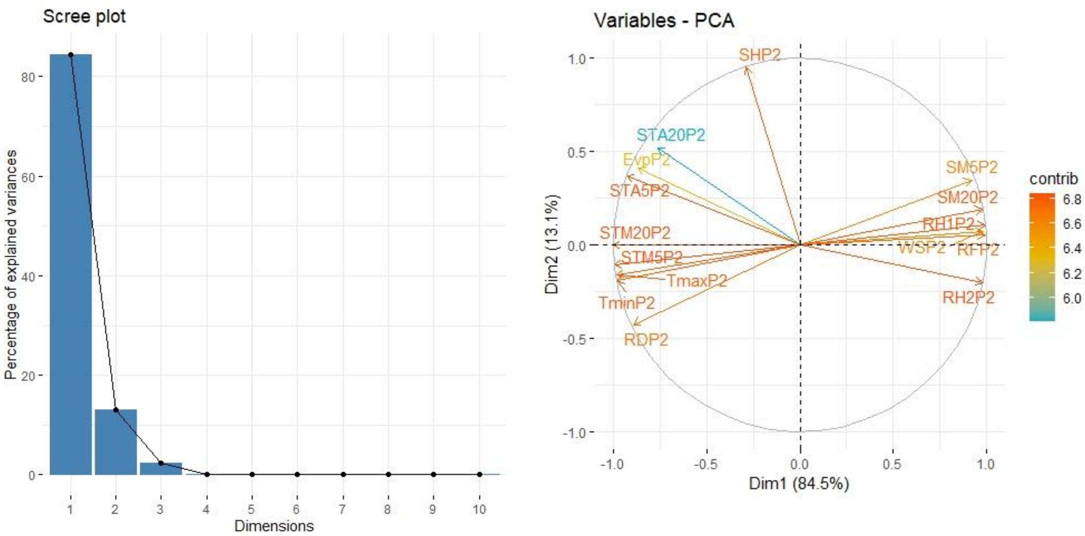


Fig 4.2 (b) Scree plot and variable factor map obtained after PCA analysis of second phenophase in black polythene mulch

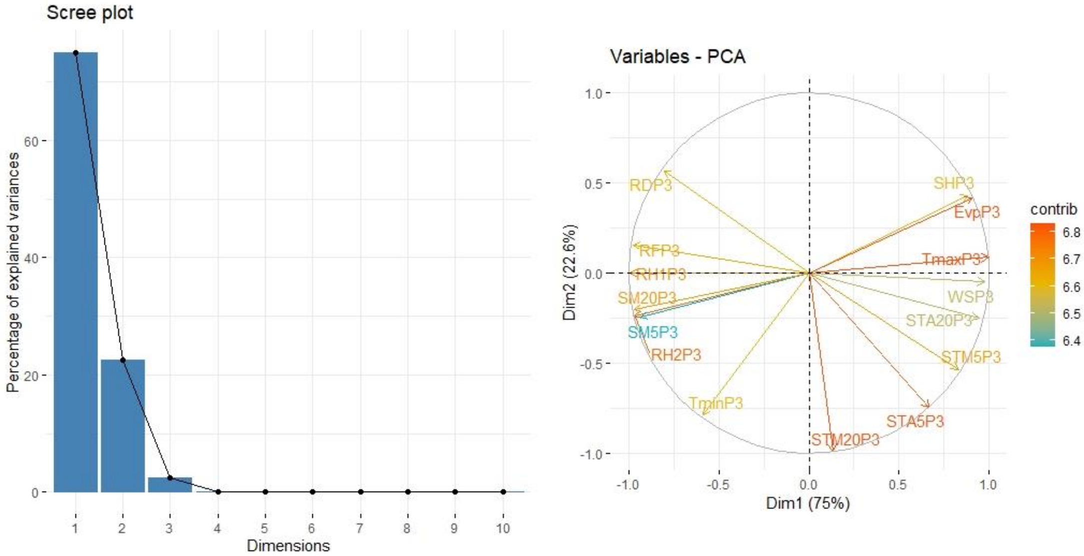


Fig 4.2 (c) Scree plot and variable factor map obtained after PCA analysis of third phenophase in black polythene mulch

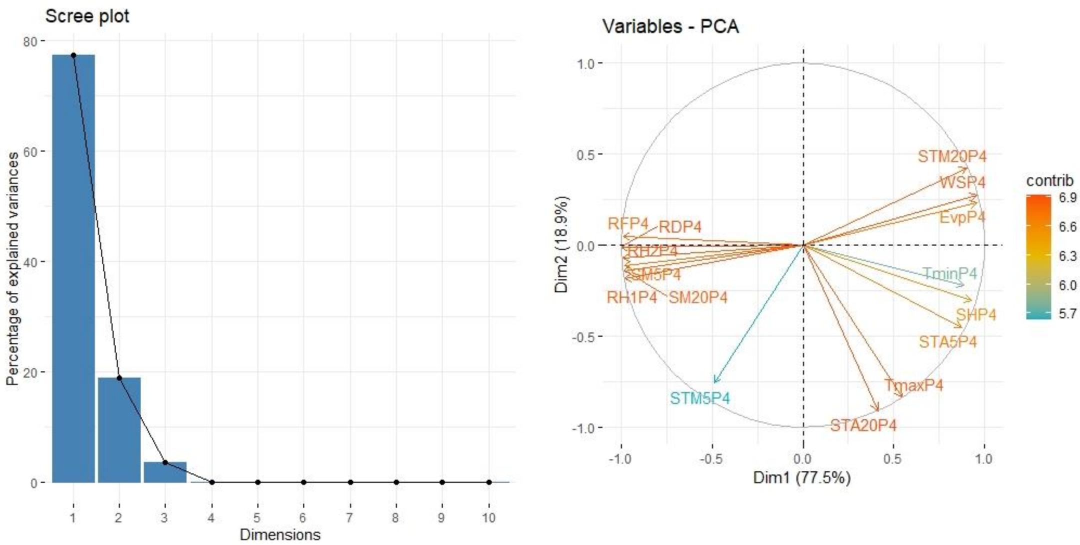


Fig 4.2 (d) Scree plot and variable factor map obtained after PCA analysis of fourth phenophase in black polythene mulch

4.9.1.3. Crop weather model using principal component analysis in paddy straw mulch (M3)

Paddy straw mulch of first phenophase planting to germination it was observed that, a cumulative proportion of 98.61 percent was obtained for the first two components (Table 4.54 (a)). Component 1 explained a 94.54 percent variance with an eigen value of 14.18 and component 2 explained 4.07 percent variance with an eigen value of 0.61. The proportion of variance was explained by a scree plot (Fig 4.3 (a)). So for the yield prediction of paddy straw mulch of first phenophase, only two components were used in fitting the regression equation. The loadings of different obtained weather variables are given in the Table 4.55 and the importance of different weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.3 (a). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (c) and Fig 4.5 (c)).

Table 4.54 (a) Important components obtained after PCA analysis of first phenophase of paddy straw mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	14.18	94.54	94.54
2	0.61	4.07	98.61

Regression equation fitted was given below

$$\mathbf{Y=33148.45-29.436X1^{**}+241.006X2^{**}}$$

In second phenophase germination to initiation of active tillering, 93.56 percent of cumulative proportion was obtained in the first two components (Table 4.54 (b)). The component 1 explained 72.34 percent variance with an eigen value of 10.85 and component 2 explained 21.22 percent variance with an eigen value of 3.18. The proportion of variance was explained by a scree plot (Fig 4.3 (b)). Variance percent of other components of variance were very little. So for the yield prediction of second phenophase only two components were used in fitting the regression equation. The loadings of different obtained weather variables are given in the Table 4.55 and the importance of different weather parameters in forming the three components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.3 (b). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (c) and Fig 4.5 (c)).

Table 4.54 (b) Important components obtained after PCA analysis of second phenophase of paddy straw mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	10.85	72.34	72.34
2	3.18	21.22	93.56

Regression equation fitted was given below

Y=240493.7-2183.64X1*+3458.631X2

The third phenopase initiation of active tillering to bulking showed a cumulative variance percent of 87.75 percent from both component 1 and component 2 (Table 4.54 (c)). The component 1 explained 69.29 percent with an eigen value of 10.39 and component 2 explained 18.45 percent variance with an eigen value of 2.76. The proportion of variance was explained by a scree plot (Fig 4.3 (c)). The yield prediction of third phenophase took only 2 components and other components were less significant. The loadings of different obtained weather variables are given in the Table 4.55 and the importance of different weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.3 (c). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (c) and Fig 4.5 (c)).

Table 4.54 (c) Important components obtained after PCA analysis of third phenophase of paddy straw mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	10.39	69.29	69.29
2	2.76	18.45	87.75

Regression equation fitted was given below

Y=-25680.7-364.19X1-87.472X2***

The cumulative variance percent of 96.49 percent was shown by both component 1 and component 2 in fourth phenopase bulking to physiological maturity (Table 4.54 (d)). The component 1 explained variance percent of 69.07 with an eigen value of 10.36 and component 2 explained a variance percent of 27.41 with an eigen value of 4.11. The proportion of variance was explained by a scree plot (Fig 4.3 (d)). Both component 1 and 2 were taken for yield prediction. The loadings of different obtained weather variables are given in the Table 4.55 and the important weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.3 (d). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (c) and Fig 4.5 (c)).

Table 4.54 (d) Important components obtained after PCA analysis of fourth phenophase of paddy straw mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	10.36	69.07	69.07
2	4.11	27.41	96.49

Regression equation fitted was given below

Y=-207017+35.587X1*-2524.86X2*

Table 4.55 Loading values of different weather variables in forming principal components of paddy straw mulch

Weather parameters	P1M3		P2M3		P3M3		P4M3	
	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2
Maximum temperature P1	-0.27	0.04	-0.29	-0.12	0.31	-0.03	0.16	-0.42
Minimum temperature P1	-0.25	0.38	-0.28	-0.13	-0.21	-0.42	0.16	-0.42
Forenoon relative humidity P1	0.26	0.20	0.30	-0.05	-0.31	0.08	-0.31	-0.08
After noon relative humidity P1	0.26	0.29	0.27	-0.24	-0.30	-0.13	-0.30	-0.05
Wind speed P1	-0.23	0.62	0.11	-0.51	0.31	-0.10	0.30	0.11
Rainfall P1	0.26	-0.19	-0.27	-0.19	-0.17	0.20	-0.30	-0.03
Rainy days P1	0.25	-0.13	-0.29	0.001	-0.05	0.43	-0.31	-0.04
Sunshine hours P1	-0.26	0.14	0.15	-0.45	0.27	0.28	0.28	-0.21
Evaporation P1	-0.25	-0.35	-0.29	-0.16	0.29	0.20	0.31	-0.06
Forenoon soil temperature at 5cm depths P1	-0.27	0.04	-0.27	-0.22	0.27	-0.04	-0.23	-0.33
Forenoon soil temperature at 20cm depths P1	-0.26	-0.23	-0.30	-0.08	0.07	-0.46	0.31	-0.01
Afternoon soil temperature at 5cm depths P1	-0.27	-0.01	0.02	-0.56	0.20	-0.45	0.10	-0.45
Afternoon soil temperature at 20cm depths P1	-0.26	-0.29	-0.30	0.05	0.30	0.11	-0.04	-0.49
Soil moisture at 5cm depth P1	0.27	0.04	-0.27	0.03	-0.30	0.12	-0.28	-0.12
Soil moisture at 20cm depth P1	0.26	0.06	-0.25	0.09	-0.31	0.03	-0.28	-0.12

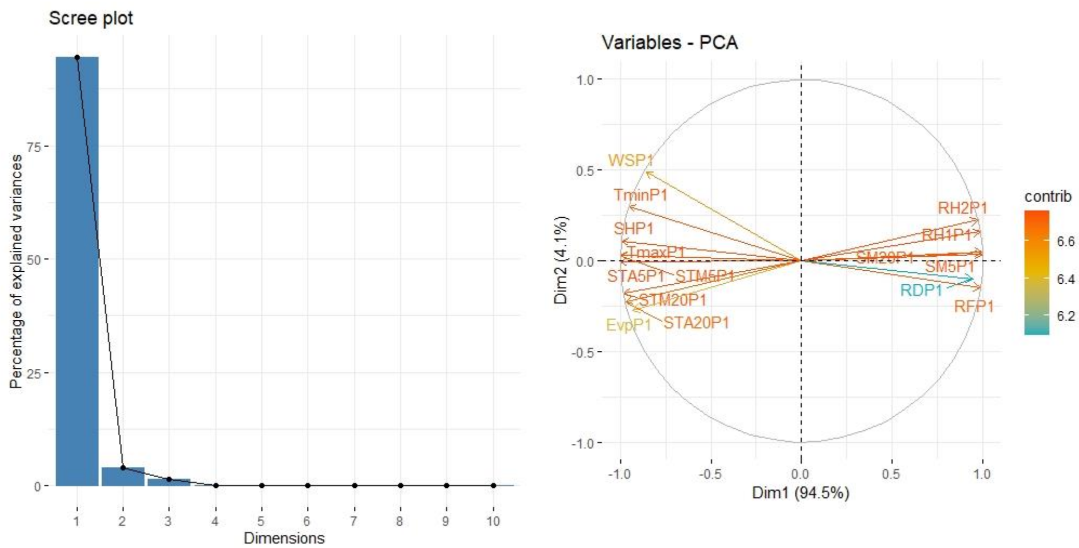


Fig 4.3 (a) Scree plot and variable factor map obtained after PCA analysis of first phenophase in paddy straw mulch

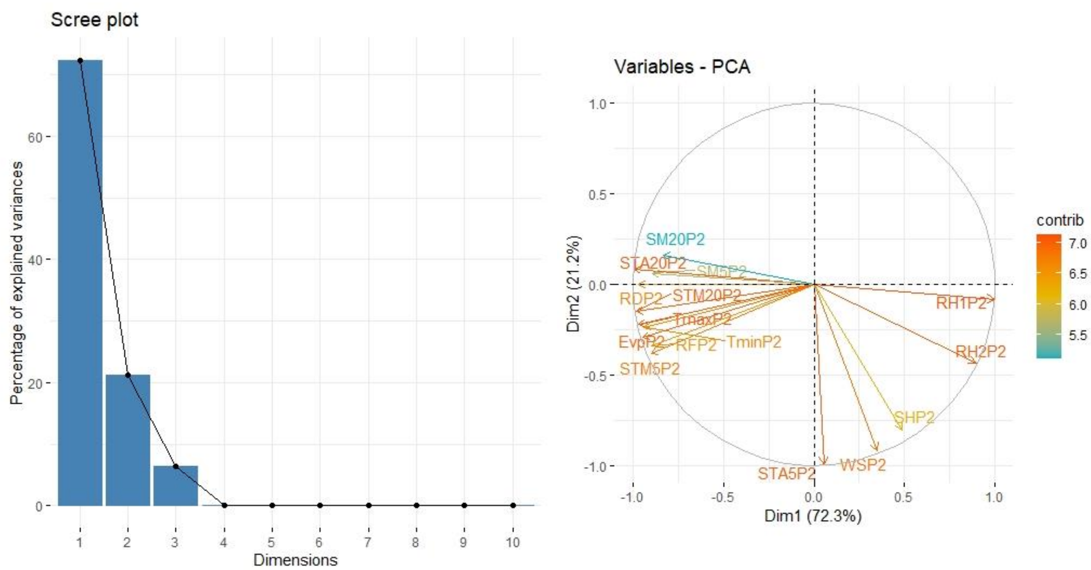


Fig 4.3 (b) Scree plot and variable factor map obtained after PCA analysis of second phenophase in paddy straw mulch

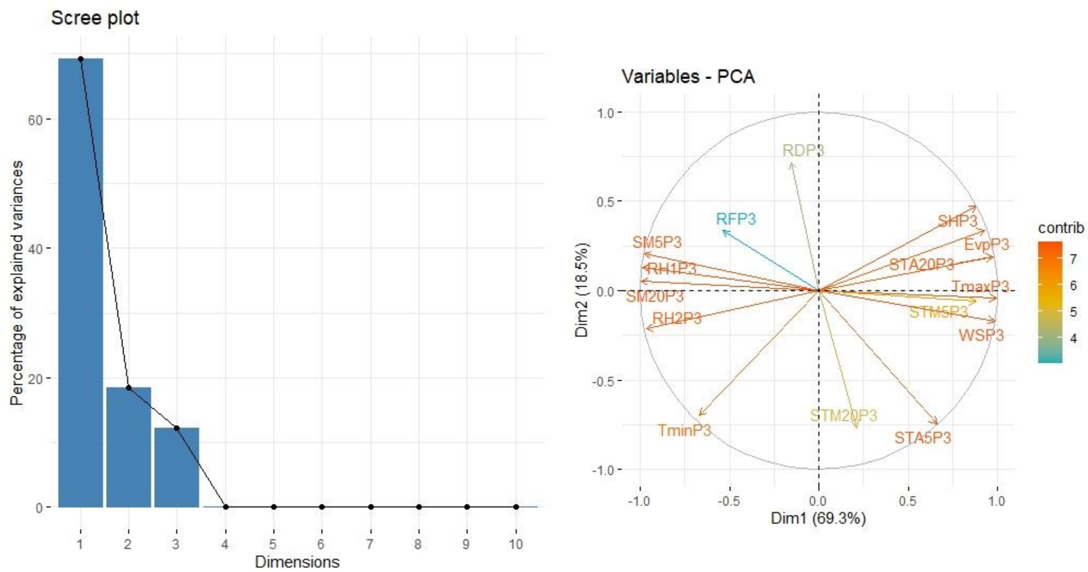


Fig 4.3 (c) Scree plot and variable factor map obtained after PCA analysis of third phenophase in paddy straw mulch

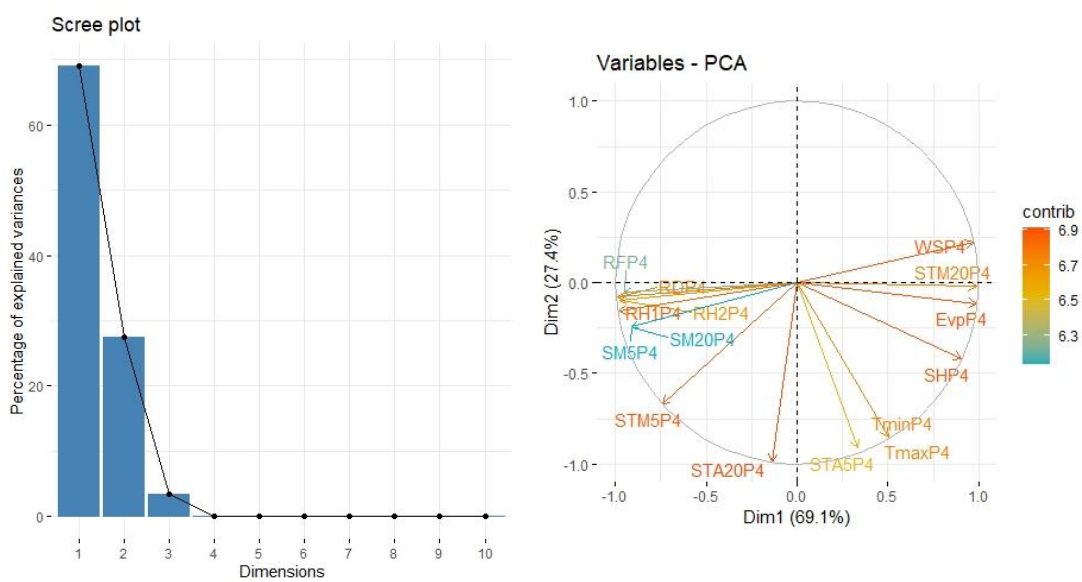


Fig 4.3 (d) Scree plot and variable factor map obtained after PCA analysis of fourth phenophase in paddy straw mulch

4.9.1.4. Crop weather model using principal component analysis in green leaf mulch (M4)

Green leaves mulch of first phenophase planting to germination showed a cumulative proportion of 98.73 percent for the first two components (Table 4.56 (a)). Component 1 explained 93.25 percent variance with an eigen value of 13.98 and component 2 explained 5.48 percent variance with an eigen value of 0.82. The proportion of variance was explained by a scree plot (Fig 4.4 (a)). In case of the other components, the proportion of variance was very less. So for the yield prediction of paddy straw mulch of first phenophase, only two components were used in fitting the regression equation. The loadings of different obtained weather variables are given in the Table 4.57 and the importance of different weather parameters in forming the three components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.4 (a). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (d) and Fig 4.5 (d)).

Table 4.56 (a) Important components obtained after PCA analysis of first phenophase of green leaves mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	13.98	93.25	93.25
2	0.82	5.48	98.73

Regression equation fitted was given below

Y=27125.16-97.764X1-4.614X2****

In second phenophase germination to initiation of active tillering, 97.06 percent of cumulative proportion was obtained in the first two components (Table 4.56 (b)). The component 1 explained 61.78 percent variance with an eigen value of 9.26 and component 2 explained 35.27 percent with an eigen value of 5.29. The proportion of variance was explained by a scree plot (Fig 4.4 (b)). Variance percent of other components of variance were very little. So for the yield prediction of second phenophase only two components were used in fitting the regression equation. The loadings of different obtained weather variables are given in the Table 4.57 and the importance of different weather parameters in forming the three components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.4 (b). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (d) and Fig 4.5 (d)).

Table 4.56 (b) Important components obtained after PCA analysis of second phenophase of green leaf mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	9.26	61.78	61.78
2	5.29	35.27	97.06

Regression equation fitted was given below

Y=-6597.59-720.671X1-203.558X2***

The third phenopase initiation of active tillering to bulking showed a cumulative variance percent of 87.75 percent from both component 1 and component 2 (Table 4.56 (c)). The component 1 explained 71.74 percent variance with an eigen value of 10.76 and component 2 explained 19.38 percent variance with an eigen value of 2.90. The proportion of variance was explained by a scree plot (Fig 4.4 (c)). The yield prediction of third phenophase took only 2 components and other components were less significant. The loadings of different obtained weather variables are given in the Table 4.57 and the importance of different weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.4 (c). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (d) and Fig 4.5 (d)).

Table 4.56 (c) Important components obtained after PCA analysis of third phenophase of green leaf mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	10.76	71.74	71.74
2	2.90	19.38	91.12

Regression equation fitted was given below

Y=15395.93-518.741X1-25.359X2**

The cumulative variance percent of 87.18 percent was shown by both component 1 and component 2 in fourth phenopase bulking to physiological maturity (Table 4.56 (d)). The component 1 explained variance percent of 65.53 with an eigen value of 9.38 and component 2 explained a variance percent of 21.65 with an eigen value of 3.24. The proportion of variance was explained by a scree plot (Fig 4.4 (d)). Both component 1 and 2 were taken for yield prediction. The loadings of different obtained weather variables are given in the Table 4.57 and the important weather parameters in forming the components were depicted in the variable factor map obtained after PCA analysis are given in Fig. 4.4 (d). The regression equations were fitted and comparison between observed yield and estimated yield were made (Table 4.58 (d) Fig 4.5 (d)).

Table 4.56 (d) Important components obtained after PCA analysis of fourth phenophase of green leaf mulch

Components	Eigen value	Variance percent	Cumulative variance percent
1	9.38	65.53	65.53
2	3.24	21.65	87.18

Regression equation fitted was given below

Y=-119557-170.673X1-1324.58X2**

Table 4.57 Loading values of different weather variables in forming principal components of green leaf mulch

Weather parameters	P1M4		P2M4		P3M4		P4M4	
	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2
Maximum temperature P1	-0.27	-0.02	-0.32	-0.11	0.30	-0.11	0.22	-0.39
Minimum temperature P1	-0.26	0.24	-0.31	-0.12	-0.23	0.20	0.24	-0.27
Forenoon relative humidity P1	0.26	0.23	0.30	0.15	-0.30	-0.06	-0.32	-0.05
After noon relative humidity P1	0.26	0.16	0.14	0.39	-0.29	0.15	-0.31	-0.03
Wind speed P1	-0.25	0.39	0.24	0.21	0.22	0.38	0.32	0.08
Rainfall P1	0.26	-0.25	-0.12	0.40	-0.07	0.57	-0.31	-0.001
Rainy days P1	0.26	-0.19	-0.30	0.18	0.003	0.55	-0.32	-0.03
Sunshine hours P1	-0.27	0.07	0.28	-0.23	0.26	-0.17	0.22	-0.02
Evaporation P1	-0.22	-0.59	-0.31	0.15	0.29	0.16	0.31	-0.12
Forenoon soil temperature at 5cm depths P1	-0.27	-0.14	-0.31	-0.14	0.30	-0.04	-0.27	-0.29
Forenoon soil temperature at 20cm depths P1	0.24	-0.42	-0.32	-0.05	0.30	-0.04	-0.001	-0.44
Afternoon soil temperature at 5cm depths P1	-0.27	-0.03	-0.02	-0.41	0.22	-0.10	0.15	-0.36
Afternoon soil temperature at 20cm depths P1	-0.27	-0.05	-0.31	-0.16	0.29	-0.02	-0.03	-0.54
Soil moisture at 5cm depth P1	0.26	0.18	-0.17	0.37	-0.27	-0.25	-0.28	-0.16
Soil moisture at 20cm depth P1	0.26	0.18	-0.18	0.36	-0.30	-0.13	-0.28	-0.16

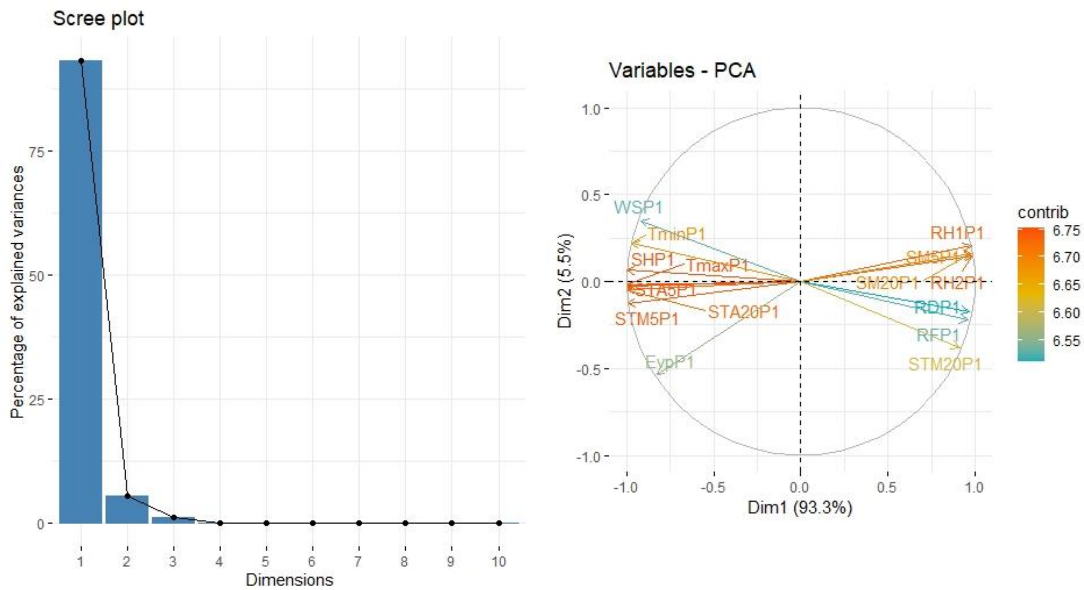


Fig 4.4 (a) Scree plot and variable factor map obtained after PCA analysis of first phenophase in green leaf mulch

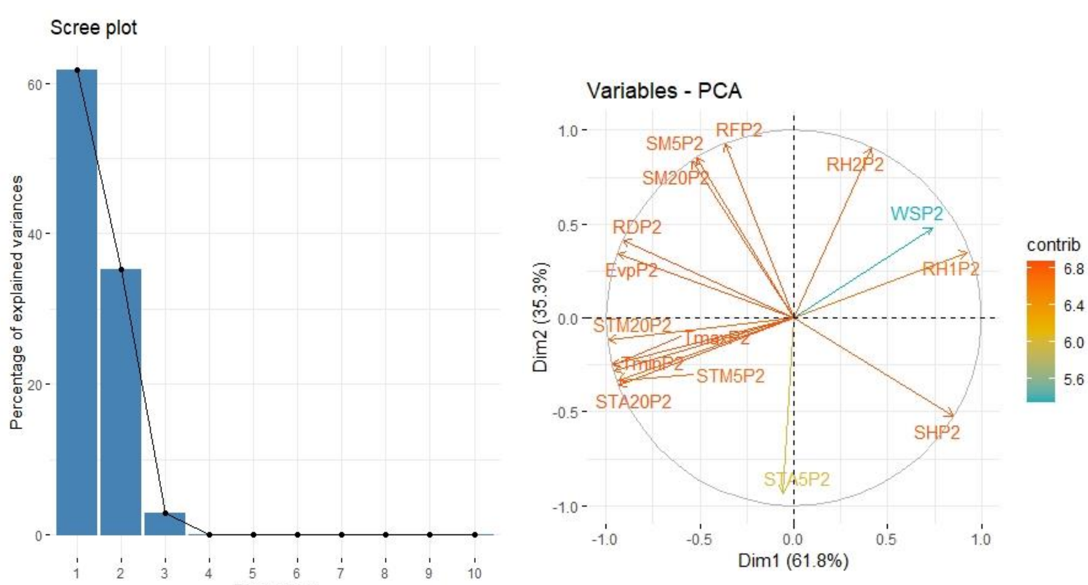


Fig 4.4 (b) Scree plot and variable factor map obtained after PCA analysis of second phenophase in green leaf mulch

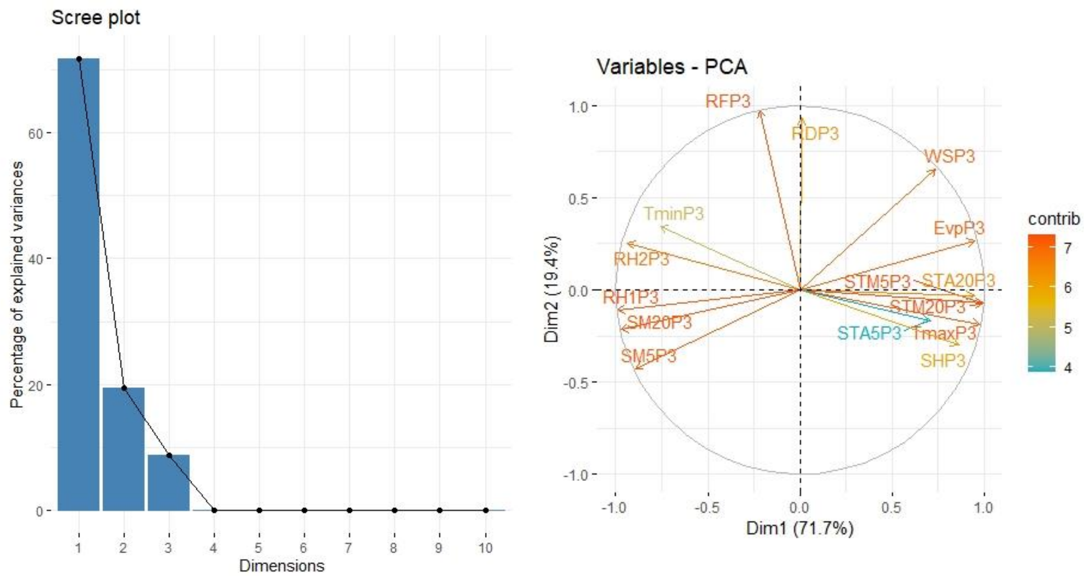


Fig 4.4 (c) Scree plot and variable factor map obtained after PCA analysis of third phenophase in green leaf mulch

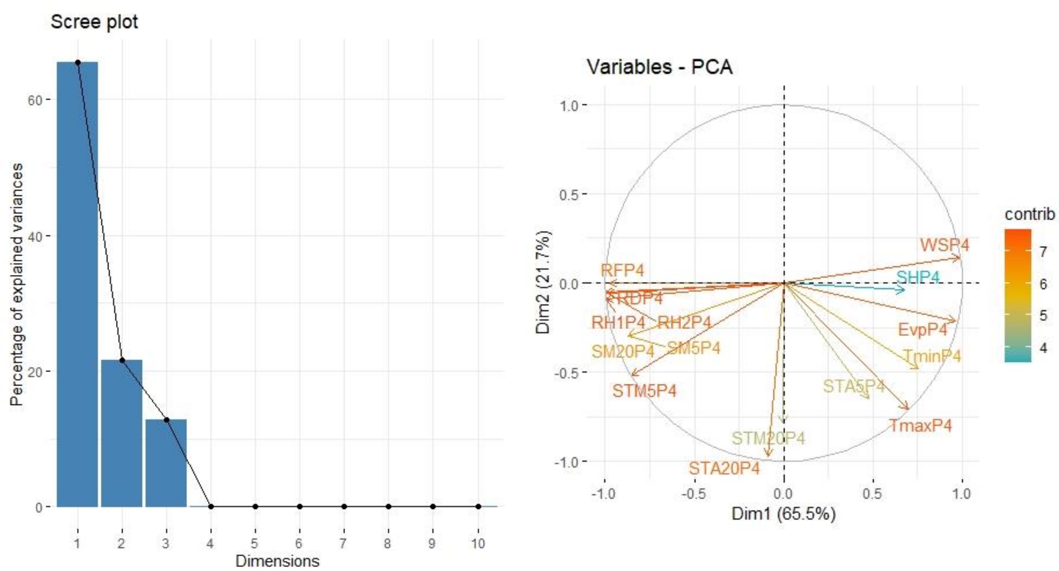


Fig 4.4 (d) Scree plot and variable factor map obtained after PCA analysis of fourth phenophase in green leaf mulch

Table 4.58 (a) Comparison of predicted and observed yield of turmeric in M1-white polythene mulch of different phenophases

Dates of planting	Yield (kg ha^{-1})				
	Observed yield	Estimated yield (P1)	Estimated yield (P2)	Estimated yield (P3)	Estimated yield (P4)
D1	22526.56	22385.08	20400.11	22736.14	21909.95
D2	20810.94	21092.88	23141.29	22057.79	22379.85
D3	20776.56	20650	19565.48	18090.64	19362.74
D4	12049.22	12035.2	13056.86	13279.52	12510.82

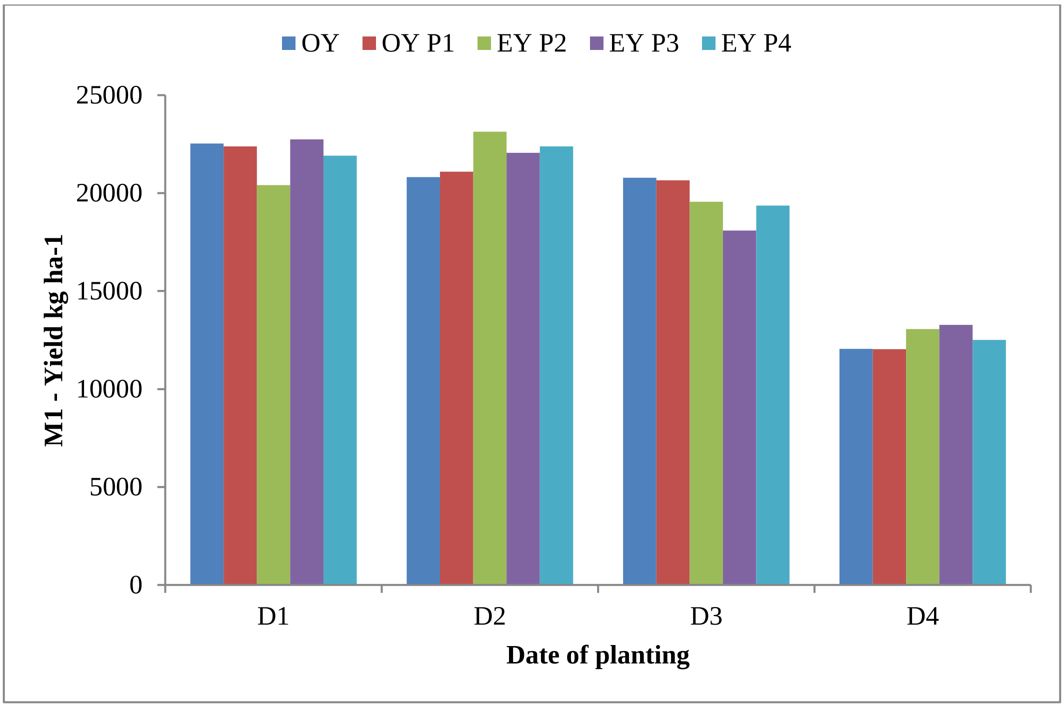


Fig. 4.5 (a) Observed and estimated yield in white polythene mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

OY- Observed yield, EYP1- Estimated yield in first phenophase, EYP2- Estimated yield in second phenophase, EYP3- Estimated yield in third phenophase and EYP4- Estimated yield in fourth phenophase

Table 4.58 (b) Comparison of predicted and observed yield of turmeric in M2-black polythene mulch of different phenophases

Dates of planting	Yield (kg ha^{-1})				
	Observed yield	Estimated yield (P1)	Estimated yield (P2)	Estimated yield (P3)	Estimated yield (P4)
D1	20943.75	20897.84	19820.69	20783.75	20775.53
D2	19660.94	19761.06	20750.53	18824.59	20140.55
D3	14444.53	14332.97	14271.36	15940.04	13195.26
D4	10065.63	10123.08	10272.49	9565.69	11003.64

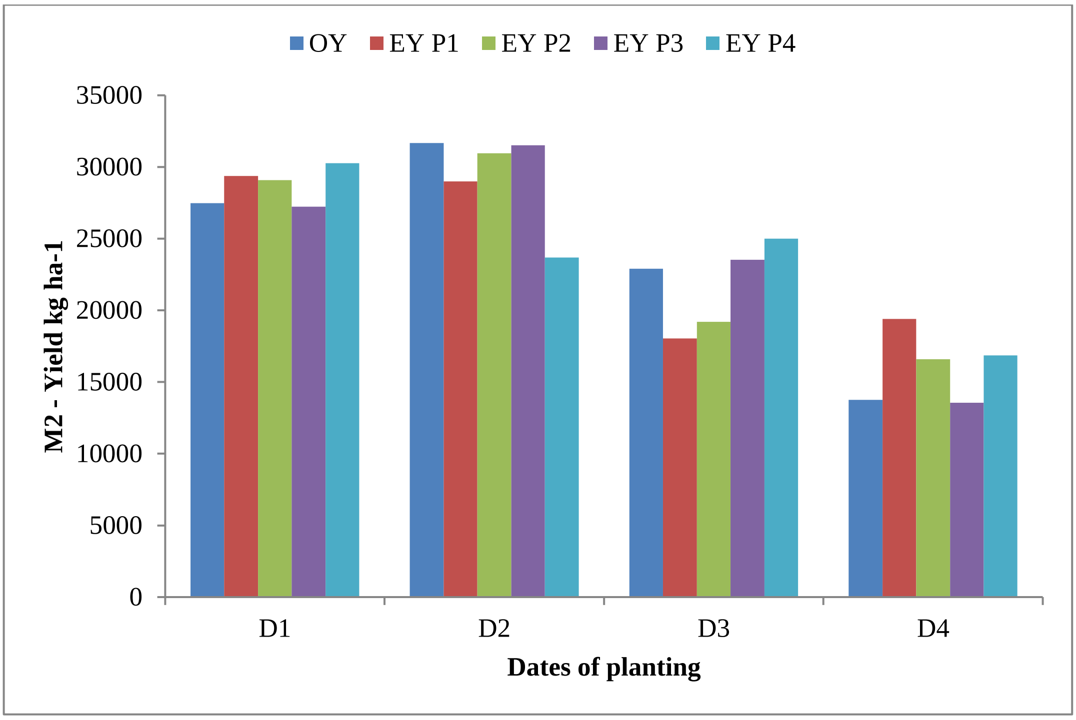


Fig. 4.5 (b) Observed and estimated yield in black polythene mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

OY- Observed yield, EYP1- Estimated yield in first phenophase, EYP2- Estimated yield in second phenophase, EYP3- Estimated yield in third phenophase and EYP4- Estimated yield in fourth phenophase

Table 4.58 (c) Comparison of predicted and observed yield of turmeric in M3-paddy straw mulch of different phenophases

Dates of planting	Yield (kg ha^{-1})				
	Observed yield	Estimated yield (P1)	Estimated yield (P2)	Estimated yield (P3)	Estimated yield (P4)
D1	27473.44	29373.1	29071.85	27232.12	30264.07
D2	31659.38	28999.21	30945.35	31507.4	23683.42
D3	22912.5	18042.4	19204.03	23517.68	25002.81
D4	13765.63	19396.16	16590.97	13553.79	16861.97

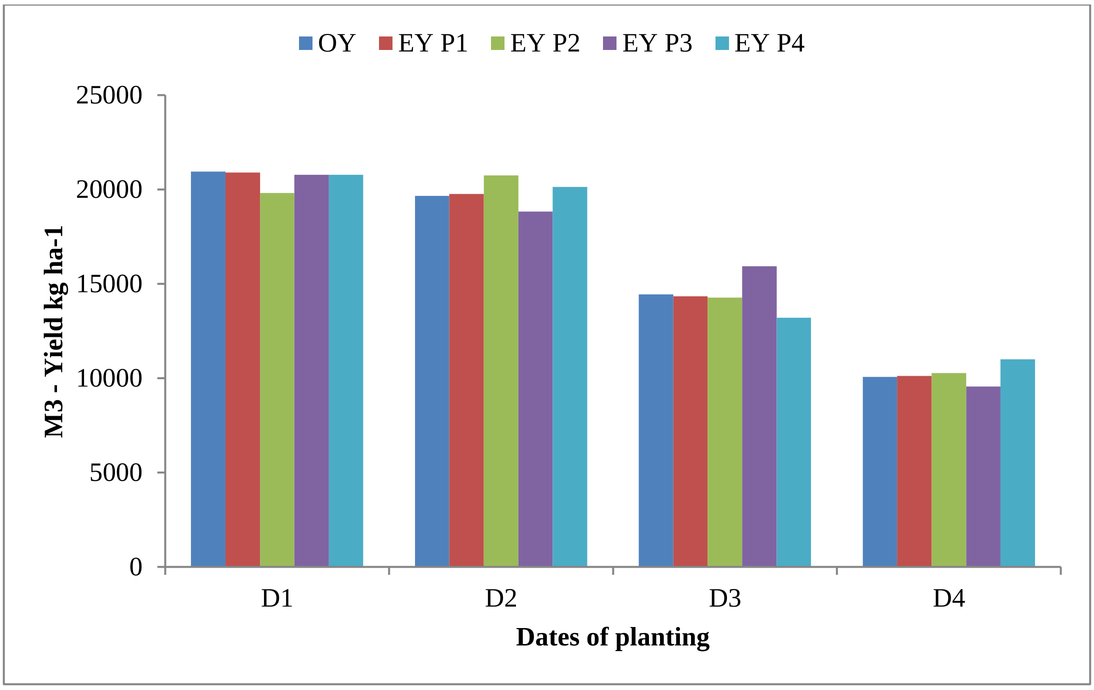


Fig. 4.5 (c) Observed and estimated yield in paddy straw mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

OY- Observed yield, EYP1- Estimated yield in first phenophase, EYP2- Estimated yield in second phenophase, EYP3- Estimated yield in third phenophase and EYP4- Estimated yield in fourth phenophase

Table 4.58 (d) Comparison of predicted and observed yield of turmeric in M4-green leaf mulch of different phenophases

Dates of planting	Yield (kg ha^{-1})				
	Observed yield	Estimated yield (P1)	Estimated yield (P2)	Estimated yield (P3)	Estimated yield (P4)
D1	26608.59	27988.25	27892.49	27378.94	28583.49
D2	27434.38	25444.36	25945.13	26886.66	21394.89
D3	19654.69	16164.32	19684.1	19088.31	21535.85
D4	12589.06	16689.68	12764.7	12932.74	14772.97

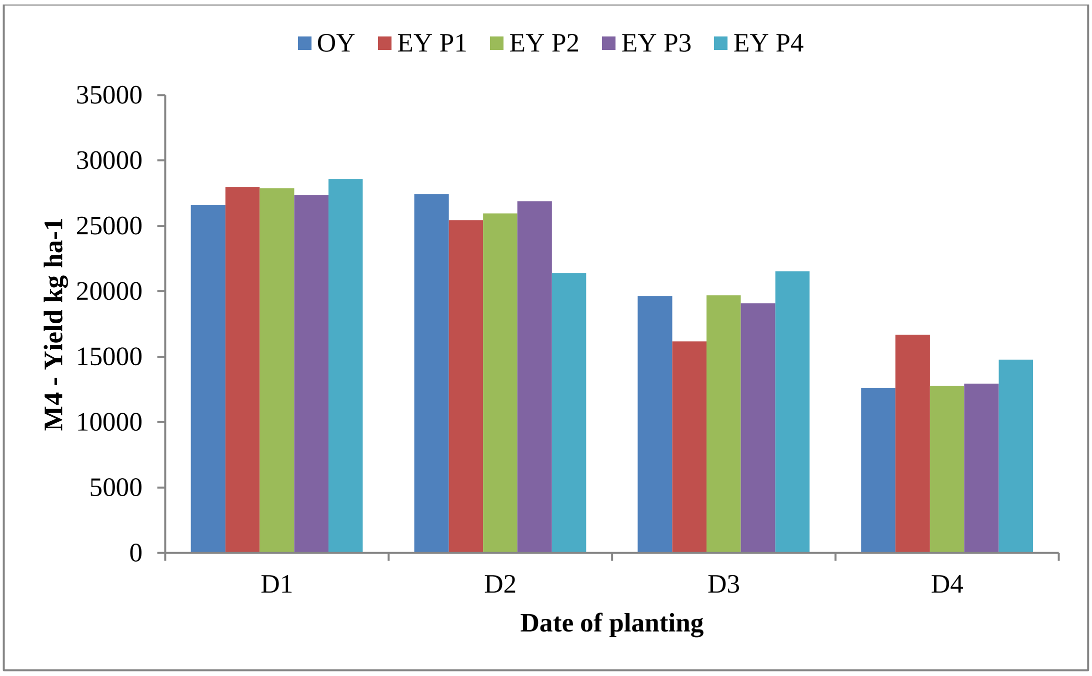


Fig. 4.5 (d) Observed and estimated yield in green leaf mulch

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

OY- Observed yield, EYP1- Estimated yield in first phenophase, EYP2- Estimated yield in second phenophase, EYP3- Estimated yield in third phenophase and EYP4- Estimated yield in fourth phenophase

Discussion

5. DISCUSSION

The study was aimed to assess the crop weather relationship of turmeric and to understand about the micrometeorological aspects of turmeric under different growing environment using different mulching treatments. The result of the study is discussed in this chapter.

5.1. EFFECT OF DATE OF PLANTING

5.1.1. Biometric observations

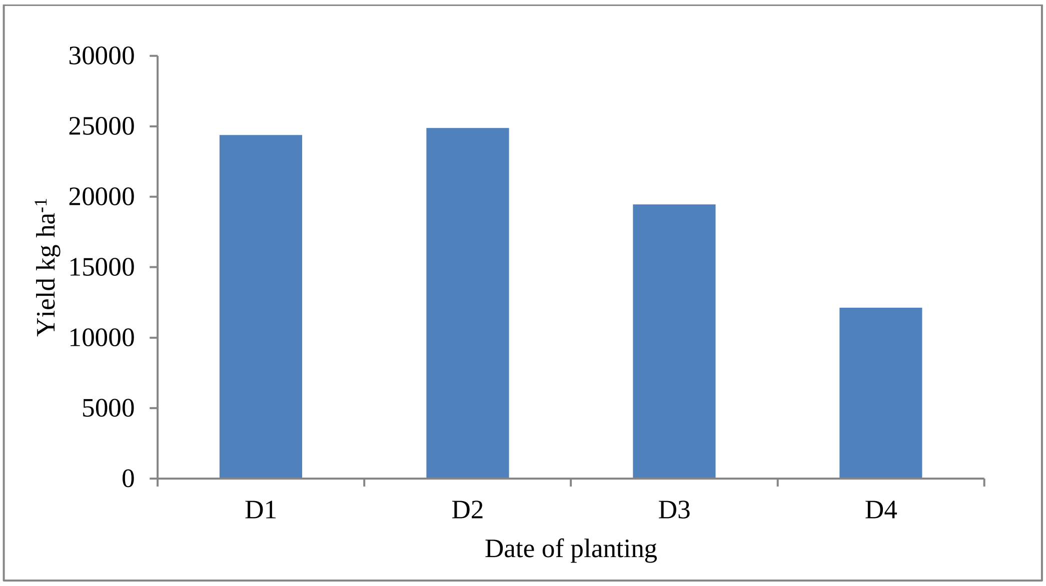
The biometric parameters like plant height, number of leaves, leaf area, number of tillers and dry matter contributions were significantly higher in earlier dates of plantings (May 1^{st} and May 15^{th}). All these biometric parameters were showing decreasing trend towards the late plantings (June 15^{th}). The plant showed maximum height in second date of planting May 15^{th}, the number of leaf and leaf area was recorded highest in first date of planting May 1^{st}, the number of tillers and dry matter accumulation was recorded highest in earlier plantings. Earlier planted crop experienced better conditions due to more growing time, less crop weed competition, good aeration, light interception, the absorption of more nutrients and minerals. This might be the reason for more growth and production of earlier crops. This result was supported by the study of Kumar et al. (2008), Kandiannan and Chandragir (2006) and Ishimine et al., (2004).

5.1.2. Phonological observations

In phonological observations the days taken to reach emergence of first tiller, emergence of last tiller and duration of the crop is significantly higher in first date of planting May 1^{st}. This trend decreases towards late date of planting. This result was supported by the study of Kandiannan et al. (2008).

5.1.3. Yield and yield attributes

The effect of dates of planting on yield and yield attributes showed that fresh yield and dry yield of the crop was higher in both May 1^{st} and May 15^{th} dates of plantings. In case of width of rhizomes, number of secondary rhizome, weight of mother rhizome, weight of primary rhizome and weight of secondary rhizome was significantly higher in first three dates of plantings (May 1st, May 15th and June 1st) (Fig 5.1). This might be due to the longer growth period of plants resulted in absorbing more nutrients and moisture content from soil in their crop period. These are in accordance with the findings of Kumar et al., (2018), Kumar and Gill (2009), Ishimine et al., (2004).



D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

Fig 5.1. Effect of date of planting on yield

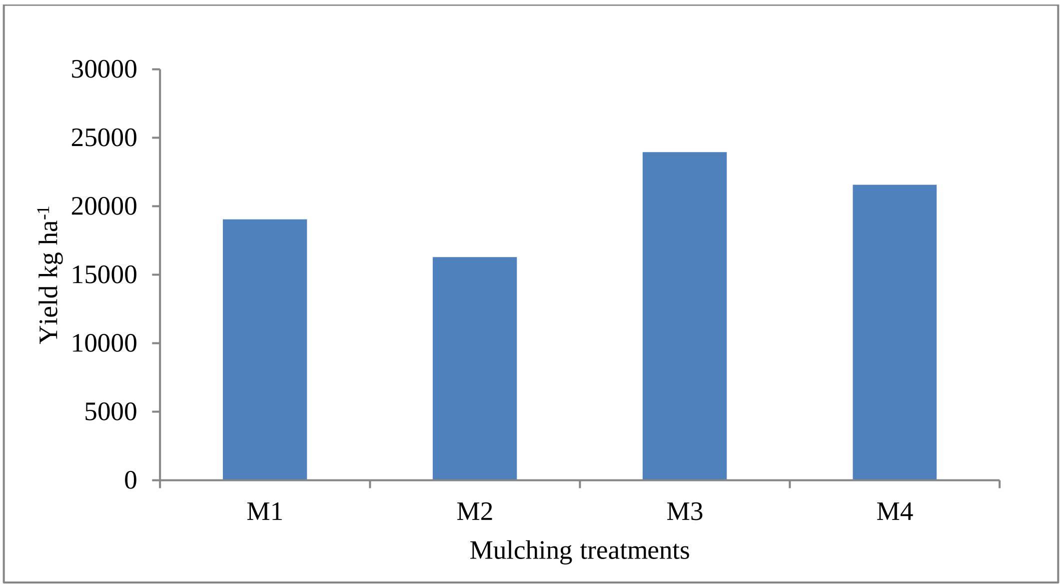
5.2. EFFECT OF MULCHING TREATMENTS

5.2.1. Biometric observations

Biometric observations showed that plant height, number of leaves, leaf area, number of tillers and dry matter accumulation were significantly higher in paddy straw mulching treatment and it was followed by green leaf mulching treatment. Similar findings have been reported by Thankamani et al., (2016), Rair et al., (2011) and Kumar et al., (2008).

5.2.2. Yield and yield attributes

Results of yield and yield attributes showed that treatment plots with paddy straw mulch produced significant more yield and yield attributes than any other treatments. The least yield and yield attributes were produced by plastic mulches (Fig 5.2). These results were supported by the findings of Pandey et al., (2020), Thankamani et al., (2016) and Kumar et al., (2008)



M1 – White polythene mulch, M2 – Black polythene mulch, M3 – Paddy straw mulch and M4 – Green leaf mulch

Fig 5.2. Effect of mulches on yield

5.3**.** CROP WEATHER RELATION

5.3.1. Biometric observations

In turmeric crop more vegetative growth was observed in the second phenophase, germination to initiation of active tillering. In this phase, height showed positive correlation with maximum temperature. This was in accordance with the result of Ishimine et al. (2004). Ishimine and his co-workers reported that shoot length and number increased significantly due to the rising temperature.

5.3.2. Phenological observations

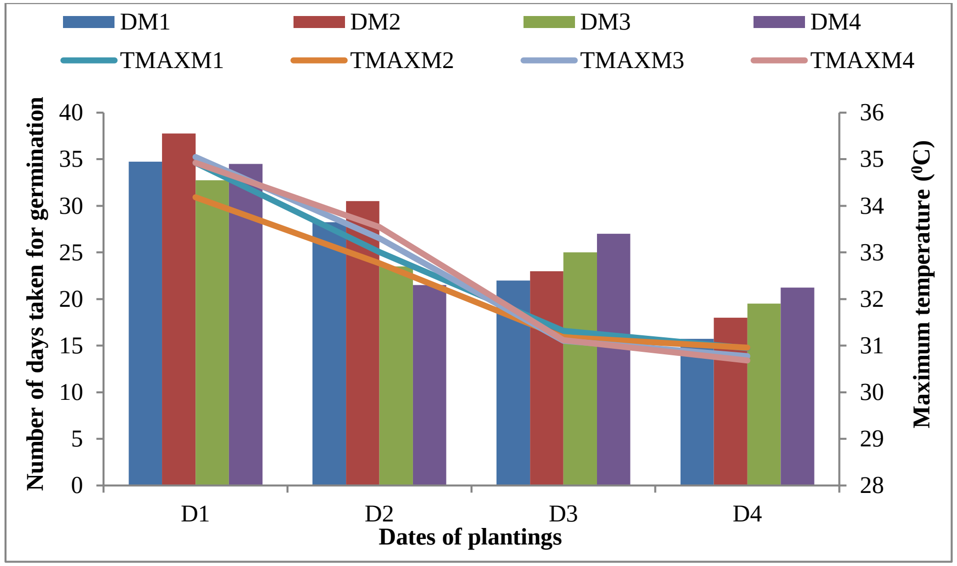
When turmeric planting was done in the beginning of the season, it allows for the accumulation of suitable thermal time, which may be sufficient to complete the phenophases in a timely manner, resulting in a larger output (Kandiannan et al., 2008). Ishimine and his co-workers in 2004 reported that, turmeric rhizomes do not sprout at a temperature below 10^0C and above 40^0C. Turmeric plants require an optimum temperature range of 25-35°C for rhizome bud sprouting and 25-30°C for seedling growth. In the first phenophase, planting to 100 per cent germination, the average temperature ranged between 30 to 35^0C and it was higher in earlier plantings (May 1st and 15th) than later plantings (July 1st and 15th). Because of this, the earlier plantings took more time to sprout and reach 100 per cent emergence than the late plantings (Fig 5.3 and 5.4).

5.3.3. Yield and yield attributes

According to Krishnamurthy and Kandiannan (2021), ginger crop at 60 DAP received 21.0 to 22.6 per cent biomass in rhizomes and 70.4 to 71.8 per cent biomass in shoots, while at 150 DAP, rhizomes received 67.0 to 73.4 per cent of total biomass and shoots received 22.4 to 29.0 per cent total biomass, which was in accordance with the third phenophase *i.e.* from active tillering to bulking.

From the study, it was found that while reaching the reproductive stage, an increase in maximum temperature was found to be decreasing the yield of turmeric in every mulching treatment. It was found that the average maximum temperature was lower in first and second dates of planting compared to third and fourth dates of planting (Fig 5.5). The yield was in accordance with the temperature, yield was observed to be higher in first and second dates of planting and the lower in third and fourth dates of planting. This was similar to the result of Kandiannan et al. (2015) and Singh (2008).

In case of minimum temperature, an increase in minimum temperature contributed an increase in yield of turmeric. The average yield and minimum temperature was higher in early dates of planting and it was lower in late date of plantings (Fig 5.6). This result was in accordance with Kandiannan et al. (2015) and Singh (2008).



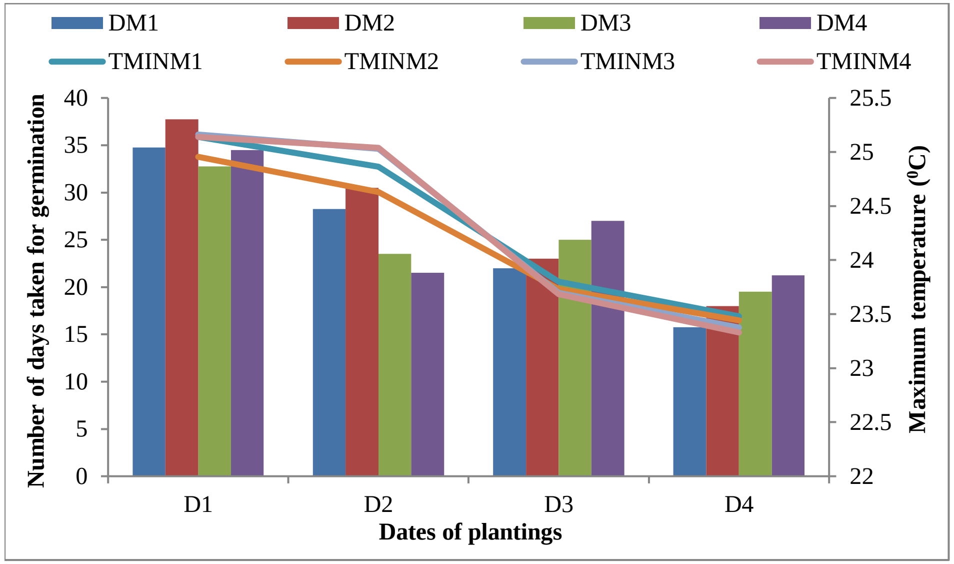


Fig 5.3. Influence of maximum temperature on number of days taken for germination

Fig 5.4. Influence of minimum temperature on number of days taken for germination

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

DM1- Days taken for germination in white polythene mulch, DM2- Days taken for germination in black polythene mulch, DM3- Days taken for germination in paddy straw mulch and DM4- Days taken for germination in green leaf mulch

TMAXM1- Maximum temperature in white ploythene mulch, TMAXM2- Maximum temperature in black ploythene mulch, TMAXM3- Maximum temperature in paddy straw mulch and TMAXM4- Maximum temperature in green leaf mulch

TMINM1- Minimum temperature in white ploythene mulch, TMINM2- Minimum temperature in black ploythene mulch, TMINM3- Minimum temperature in paddy straw mulch and TMINM4- Minimum temperature in green leaf mulch

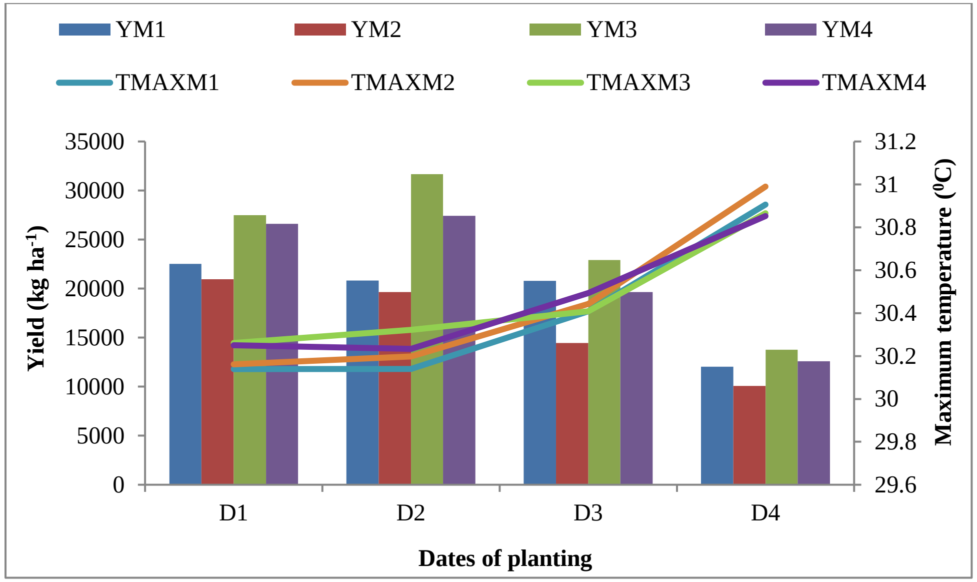


Fig 5.5. Influence of maximum temperature during 3rd phenophase on yield

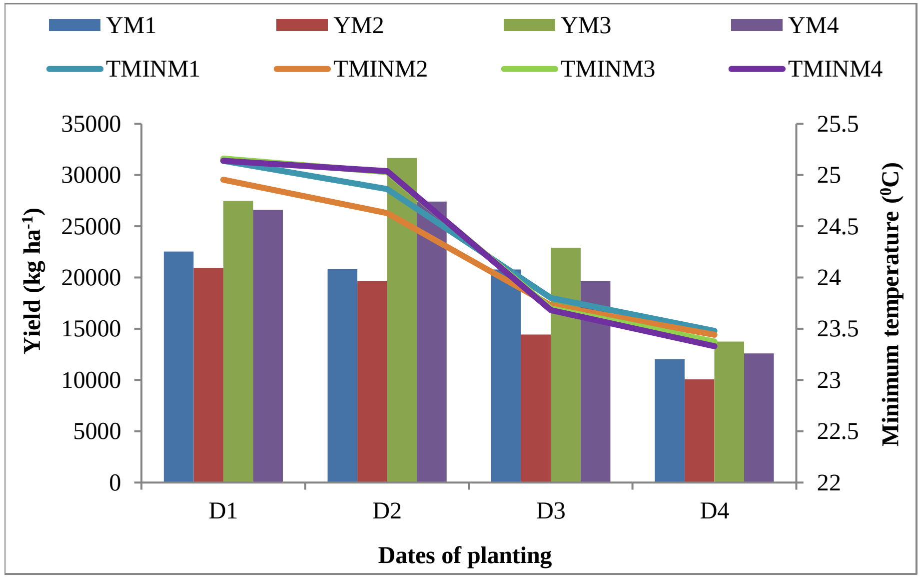


Fig 5.6. Influence of minimum temperature during 3rd phenophase on yield

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

YM1- Yield in white polythene mulch, YM2- Yield in black polythene mulch, YM3- Yield in paddy straw mulch and YM4- Yield in green leaf mulch

TMAXM1- Maximum temperature in white ploythene mulch, TMAXM2- Maximum temperature in black ploythene mulch, TMAXM3- Maximum temperature in paddy straw mulch and TMAXM4- Maximum temperature in green leaf mulch

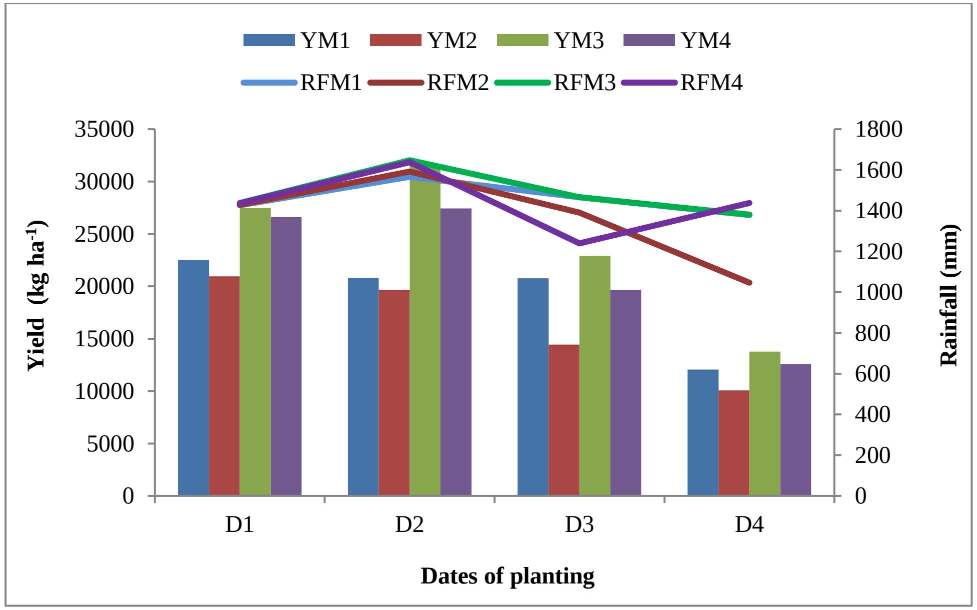
TMINM1- Minimum temperature in white ploythene mulch, TMINM2- Minimum temperature in black ploythene mulch, TMINM3- Minimum temperature in paddy straw mulch and TMINM4- Minimum temperature in green leaf mulch

The experimental results showed that rainfall had a positive correlation with yield. The increased cumulative rain fall during the reproductive and maturity phases resulted in increased yield of the crop. Due to more growing period in the earlier planting dates, the cumulative rain fall was high (Fig 5.7). This resulted in more yield than later planted crops in all mulching treatments (Kandiannan et al., 2015 and Singh., 2008).

In the earlier vegetative phases *i.e,* Planting to germination and germination to active tillering, it was observed that increase in relative humidity resulted in decrease in yield. In later phases during reproductive growth stages, the increase in relative humidity resulted in increase in yield of the turmeric (Fig 5.8). This is in accordance with the results of Kandiannan et al., 2015.

Bright sunshine hours showed negative correlation with yield (Fig 5.9). Kandiannan et al. (2015) and Singh. (2008) also reported that increase in sunshine hours resulted in declining of yield.

Wind speed showed negative correlation with yield in the third and fourth phenophases, the increased wind speed resulted in reduction of yield (Fig 5.10). The yield and wind speed of late plantings showed that, the late planted crops experienced more wind, which might have resulted in reducing the yield comparing to earlier plantings (Kandiannan et al., 2015).



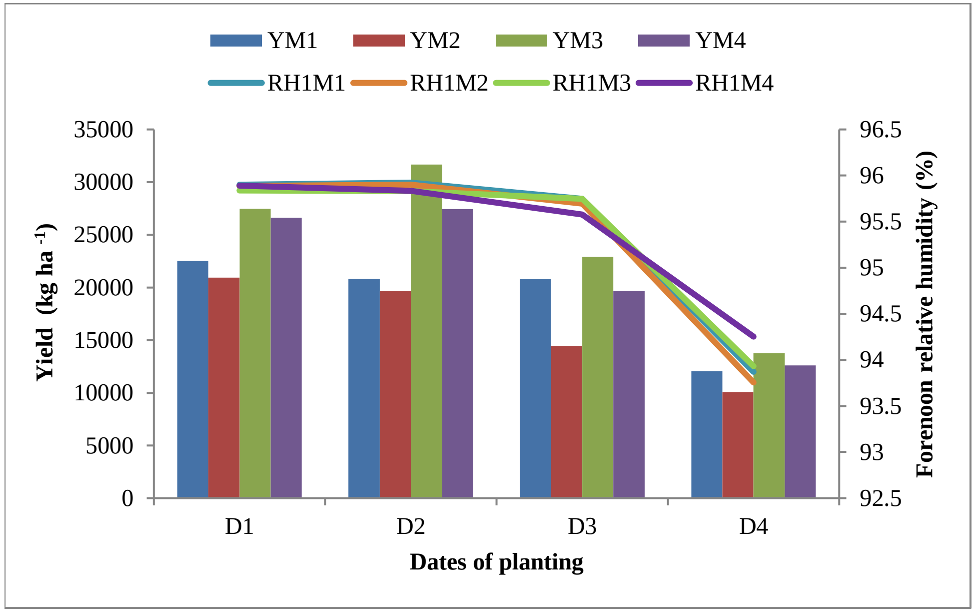


Fig 5.7. Influence of rainfall during 3rd phenophase on yield

Fig 5.8. Influence of forenoon relative humidity during 3rd phenophase on yield

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

YM1- Yield in white polythene mulch, YM2- Yield in black polythene mulch, YM3- Yield in paddy straw mulch and YM4- Yield in green leaf mulch

RFM1- Rainfall in white ploythene mulch, RFM2- Rainfall in black ploythene mulch, RFM3- Rainfall in paddy straw mulch and RFM4- Rainfall in green leaf mulch

RH1M1- Forenoon relative humidity in white ploythene mulch, RH1M2- Forenoon relative humidity in black ploythene mulch, RH1M3- Forenoon relative humidity in paddy straw mulch and RH1M4- Forenoon relative humidity in green leaf mulch

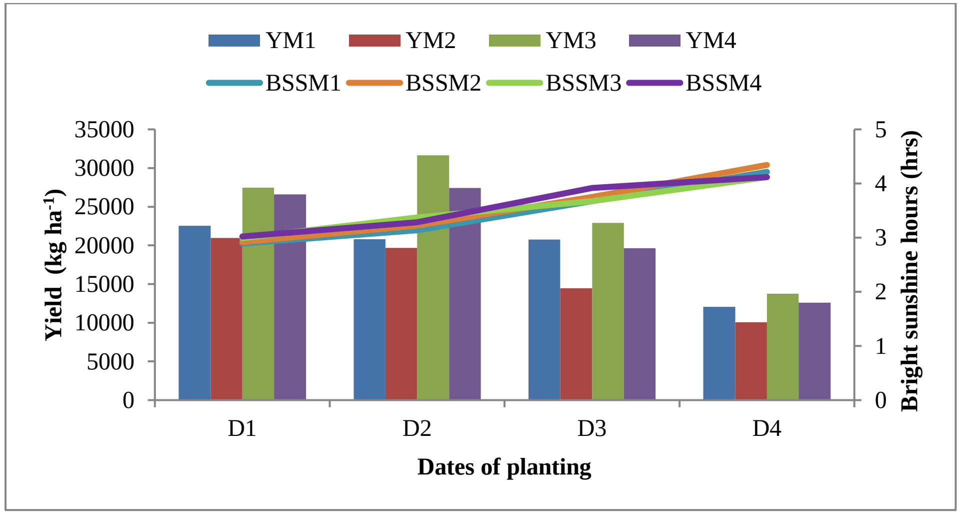


Fig 5.9. Influence of bright sunshine hours during 3rd phenophase on yield

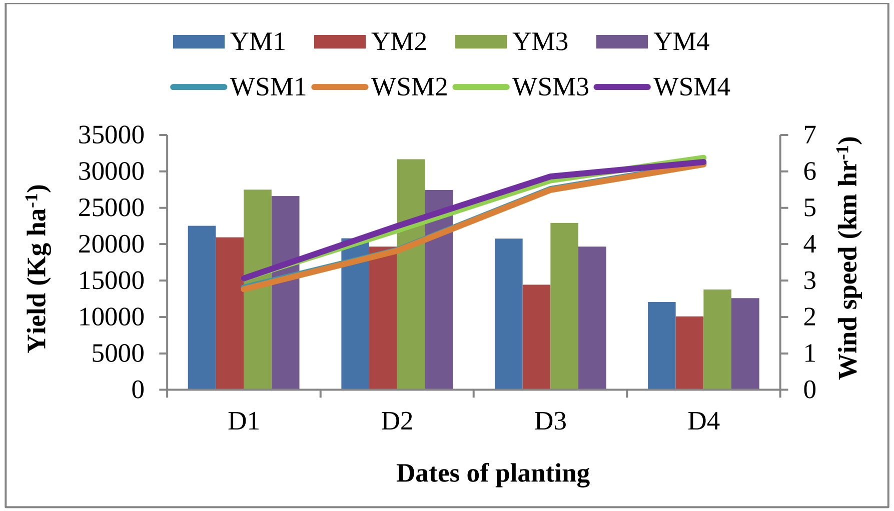


Fig 5.10. Influence of wind speed during 3rd phenophase on yield

D1 – 1st May, D2 – 15th May, D3 – June 1st and D4 – June 15th

BSSM1- Bright sunshine hours in white ploythene mulch, BSSM2- Bright sunshine hours in black ploythene mulch, BSSM3- Bright sunshine hours in paddy straw mulch and BSSM4- Bright sunshine hours in green leaf mulch

YM1- Yield in white polythene mulch, YM2- Yield in black polythene mulch, YM3- Yield in paddy straw mulch and YM4- Yield in green leaf mulch

WSM1- Wind speed in white ploythene mulch, WSM2- Wind speed in black ploythene mulch, WSM3- Wind speed in paddy straw mulch and WSM4- Wind speed in green leaf mulch

Summary

6. SUMMARY

The research on "micrometeorological modification with mulches to enhance the yield of turmeric (*Curcuma longa* L.)" was conducted at department of Agricultural Meteorology, College of Agriculture, Vellanikkara during 2020 to 2021. The crop weather relationship was studied under four different dates of planting and four different mulching treatments.

Different observations like weather observations, micrometeorological observations, soil parameters, biometric parameters, phonological observations, yield and yield attributes were taken to assess the crop weather relationship of turmeric. From the crop weather relationship, yield prediction models were developed for each phenophases of turmeric.

- The total crop period was divided in to four phenophases i.e. P1- planting to germination, P2- germination to initiation of active tillering, P3- initiation of active tillering to bulking and P4 bulking to physiological maturity
- The earlier dates of planting (May 1st and May 15th) took more days and June 15th date of planting took least days to attain physiological maturity
- Plant height showed that May 15th date of planting recorded highest plant height in date of plantings. In case of mulching treatments, both organic mulches (straw and green leaf mulch) produced more plant height and they were on par
- The total number of leaves was recorded to be high in May 1st and 15th date of plantings. It was recorded to be more in both organic mulches (straw and green leaf mulch) and they were on par
- Maximum leaf area was recorded during the 33rd meteorological week of the crop growth and it was found to be high in 1st, 2nd and 3rd dates of planting (May 1st, May 15th and June 1st) and they were on par

- The total number of tillers were recorded from the second phenophase and it was recorded to be high in 1^{st}, 2^{nd} and 3^{rd} dates of planting (May 1^{st}, May 15^{th} and June 1^{st}) and they were on par

- Maximum dry matter accumulation was recorded in 6^{th} month and it was on par in case of 1^{st} and 2^{nd} dates of planting (May 1^{st} and May 15^{th}) and also in organic mulches (straw and green leaf)

- The fresh and dry yield produced similar results. They were high and on par in May 1^{st} and May 15^{th} dates of planting. Paddy straw mulch produced highest yield and it was followed by green leaves

- The first phenophase of 1^{st} date of planting recorded high maximum, minimum and soil temperature along with less rainfall and rainy days. This might have influenced the late emergence of turmeric

- The increase in minimum temperature and relative humidity during the bulking stage resulted in the increase of turmeric yield. Whereas the increase in maximum temperature, bright sunshine hours and evaporation during the bulking stage decreased the yield of turmeric

- Soil moisture content and relative humidity inside the plant canopy showed a positive correlation with yield. Whereas soil temperature showed a negative correlation with yield during the bulking stage of turmeric

- Crop yield predictions models were developed for all the phenophases, at four dates of planting and four types of mulches with the help of principal component analysis (PCA) and it was found that weather parameters at third phenophase were more suitable for predicting the turmeric yield

- The observed and estimated yields were in accordance with each other

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Appendices

Appendix I

Abbreviations and units used

Dates of planting

D1 – 1st May

D2 – 15th May

D3 – 1st June

D4 – 15th June

Mulches

M1 – White polythene mulch

M2 – Black polythene mulch

M3 – Paddy straw mulch

M4 – Green leaf mulch

Weather parameters

TMAX : Maximum temperature

TMIN : Minimum temperature

RH1 : Forenoon relative humidity

RH2 : Afternoon relative humidity

RF : Rainfall

RD : Rainy days

WS : Wind speed

SH : Sunshine hours

EVP : Evaporation

Micrometeorological parameters

STM5 : Forenoon soil temperature at 5 cm depth

STM20 : Forenoon soil temperature at 5 cm depth

STA5 : Afternoon soil temperature at 5 cm depth

STA20 : Afternoon soil temperature at 20 cm depth

SM5 : Soil moisture at 5 cm depth

SM20 : Soil moisture at 20 cm depth

RHMP : Forenoon relative humidity inside plant canopy

RHAP : Afternoon relative humidity inside plant canopy

Appendix I (contd.)

Phenophases	**Units**	
P1: Planting to germination	^0C	: Degree celcius
P2: Germination to initiation of active tillering	%	: Percentage
P3: Active tillering to bulking	Km hr^{-1}	: Kilo meter per hour
P4: Bulking to physiological maturity	hrs	: Hours
	mm	: Milli meter
	cm	: Centimetre
	cm^2	: Square centimetre

Days taken in mulches	**Yield in mulches**
DM1 – Days taken in white polythene mulch	YM1 – Yield in white polythene mulch
DM2 – Days taken in black polythene mulch	YM2 – Yield in black polythene mulch
DM3 – Days taken in paddy straw mulch	YM3 – Yield in paddy straw mulch
DM4 – Days taken in green leaf mulch	YM4 – Yield in green leaf mulch

Appendix I (contd.)

Weather parameters experienced in mulching practices

TMAXM1 – Maximum temperature in white polythene mulch

TMAXM2 – Maximum temperature in black polythene mulch

TMAXM3 – Maximum temperature in paddy straw mulch

TMAXM4 – Maximum temperature in green leaf mulch

TMINM1 – Minimum temperature in white polythene mulch

TMINM2 – Minimum temperature in black polythene mulch

TMINM3 – Minimum temperature in paddy straw mulch

TMINM4 – Minimum temperature in green leaf mulch

RH1M1 – Forenoon relative humidity in white polythene mulch

RH1M2 – Forenoon relative humidity in black polythene mulch

RH1M3 – Forenoon relative humidity in paddy straw mulch

RH1M4 – Forenoon relative humidity in green leaf mulch

BSSM1 – Bright sunshine hours in white polythene mulch

BSSM2 – Bright sunshine hours in black polythene mulch

BSSM3 – Bright sunshine hours in paddy straw mulch

BSSM4 – Bright sunshine hours in green leaf mulch

RFM1 – Rainfall in white polythene mulch

RFM2 – Rainfall in black polythene mulch

RFM3 – Rainfall in paddy straw mulch

RFM4 – Rainfall in green leaf mulch

Appendix I (contd.)

WSM1 – Wind speed in white polythene mulch

WSM2 – Wind speed in black polythene mulch

WSM3 – Wind speed in paddy straw mulch

WSM4 – Wind speed in green leaf mulch

Observed and estimated yields

OY – Observed yield

EYM1 – Estimated yield in white polythene mulch

EYM2 – Estimated yield in black polythene mulch

EYM3 – Estimated yield in paddy straw mulch

EYM4 – Estimated yield in green leaf mulch

Appendix II

Equations used

Leaf area (cm^2) = (leaf length * leaf width) * 0.72

Appendix III

ANOVA of different plant growth characters of 2019-2020 experiment

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	1st week	2nd week	3rd week	4th week	5th week
Dates of planting	3	216.081***	516.03***	1301.26***	2277.73***	3432.9***
Error (a)	9	10.474	17.95	34.42	42.55	60.0
Mulches	3	105.240***	222.31***	488.57***	720.44***	992.9***
DOP x Mulches	9	7.574	12.73	31.61	47.57	67.1
Error	36	7.845	9.84	17.83	29.44	40.6

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	6th week	7th week	8th week	9th week	10th week
Dates of planting	3	4044.1***	3671.8***	4272.7***	5046.9***	5599.2***
Error (a)	9	96.4	127.7	199.0	201.2	169.4
Mulches	3	1239.4***	1341.5***	1342.6	1085.1***	1253.6 ***
DOP x Mulches	9	87.0	90.6	100.6	103.8	110.9
Error	36	54.1	64.2	76.7	90.3	96.7

Appendix III (contd.)

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	11th week	12th week	13th week	14th week	15th week
Dates of planting	3	6420.3***	5764.8***	5203.7 ***	4952.8 ***	5250.0 ***
Error (a)	9	179.7	177.3	175.6	200.5	250.9
Mulches	3	1337.8 ***	1482.3 ***	1488.2 ***	1450.6 ***	1306.6 ***
DOP x Mulches	9	111.8	103.3	114.7	114.1	97.9
Error	36	111.1	122.6	133.8	130.8	118.8

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	16th week	17th week	18th week	19th week	20th week
Dates of planting	3	5591.2 ***	5857.3 ***	6287.5 ***	6200.1 ***	6282.3***
Error (a)	9	143.1	106.7	102.3	101.4	105.1
Mulches	3	1253.2 ***	1131.1 ***	1022.1 ***	994.5 ***	972.3 ***
DOP x Mulches	9	98.7	89.5	77.3	61.3	45.0
Error	36	105.2	85.4	66.6	56.9	50.1

Appendix III (contd.)

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	21st week	22nd week	23rd week	24th week	25th week
Dates of planting	3	7107.3***	7898.2 ***	8739.7 ***	9338.7 ***	9629.2 ***
Error (a)	9	103.9	99.6	102.7	107.6	99.3
Mulches	3	949.7 ***	965.4 ***	948.9 ***	937.4 ***	775.9 ***
DOP x Mulches	9	35.0	34.7	36.7	40.9	61.7
Error	36	45.0	40.0	35.2	32.4	36.5

Plant height at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	26th week	27th week	28th week	29th week	30th week
Dates of planting	3	9794.3 ***	9971.1 ***	10204.1 ***	10159.4 ***	9976.7 ***
Error (a)	9	96.8	91.2	86.4	87.0	87.1
Mulches	3	903.0 ***	894.3 ***	854.3 ***	862.9 ***	831.5 ***
DOP x Mulches	9	34.3	29.8	27.9	25.8	25.9
Error	36	29.2	28.1	27.0	27.1	26.5

Appendix III (contd.)

Number of leaves at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	1st week	3rd week	5th week	7th week	9th week
Dates of planting	3	2.16896***	10.4590***	10.3692***	6.1373***	11.9108**
Error (a)	9	0.07174	0.1673	0.1453	0.2006	0.8947
Mulches	3	1.47062***	0.5273*	0.3975*	0.3523	0.4625
DOP x Mulches	9	0.11563	0.1145	0.2197	0.1934	0.2242
Error	36	0.10604	0.1288	0.1164	7.6925	0.2549

Number of leaves at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	11th week	13th week	15th week	17th week	19th week
Dates of planting	3	4.4406*	3.5206**	2.19396 **	4.8175	7.1217***
Error (a)	9	0.9223	0.3647	0.22618	0.1925	0.2033
Mulches	3	0.2790	0.2406	0.37396	0.1875	0.1500
DOP x Mulches	9	0.2067	0.1359	0.10896	0.1714	0.1817
Error	36	0.2442	0.2106	0.19910	0.1776	0.1271

Appendix III (contd.)

Number of leaves at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	21st week	23rd week	25th week	27th week	29th week
Dates of planting	3	7.2675***	9.1567***	10.7223***	10.7223***	10.7223***
Error (a)	9	0.2319	0.1867	0.1590	0.1590	0.1590
Mulches	3	0.1008	0.0867	0.0273	0.0473	0.0473
DOP x Mulches	9	0.1481	0.1378	0.1584	0.1562	0.1562
Error	36	0.1274	0.1289	0.1573	0.1562	0.1562

x

Leaf area at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	1st week	3rd week	5th week	7th week	9th week
Dates of planting	3	2035.76*	5828.2*	23067.6**	69372**	416538***
Error (a)	9	456.77	980.7	1828.3	9469	19032
Mulches	3	651.26	3581.6*	16462.5***	28997**	27845
DOP x Mulches	9	412.85	1045.0	2838.2	9178	5853
Error	36	301.46	920.0	2064.3	6442	16406

Appendix III (contd.)

Number of leaf area at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	11th week	13th week	15th week	17th week	19th week
Dates of planting	3	307462**	358165 **	972913***	813369***	690009***
Error (a)	9	28265	36332	37697	28455	13476
Mulches	3	86368	6767	49426*	47590	45042*
DOP x Mulches	9	9771	8108	6457	9580	11560
Error	36	18189	12341	13469	14506	12539

Number of leaf area at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	21st week	23rd week	25th week	27th week	29th week
Dates of planting	3	714606***	567216***	631428***	632223***	619516***
Error (a)	9	11281	14882	14441	10743	11996
Mulches	3	53502	30139	31718	39774*	34416
DOP x Mulches	9	7384	11393	10263	8437	10283
Error	36	13404	14456	12827	13755	12541

Appendix III (contd.)

Number of tillers at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	1st week	2nd week	3rd week	4th week	5th week
Dates of planting	3	0.140625	1.95563**	2.60333***	4.8040**	3.4142***
Error (a)	9	0.118403	0.15507	0.06611	0.3823	0.1503
Mulches	3	0.127292 *	0.17396	0.27333	0.2240	0.2108
DOP x Mulches	9	0.045069	0.15118	0.31889 *	0.3023	0.2936
Error	36	0.039514	0.10576	0.12806	0.1805	0.2201

Number of tillers at different weeks after planting

Sources of variation	Mean sum of squares					
	DF	6th week	7th week	8th week	9th week	10th week
Dates of planting	3	3.4142***	3.3950***	2.19750***	2.19750***	2.55750***
Error (a)	9	0.1503	0.1300	0.08250	0.08250	0.09694
Mulches	3	0.2108	0.2683	0.23417	0.23417	0.21583
DOP x Mulches	9	0.2936	0.2822	0.29139	0.29139	0.28417
Error	36	0.2201	0.2043	0.20431	0.20431	0.16264

Appendix III (contd.)

Number of days taken to phonological observations

Sources of variation	Mean sum of squares		
	Emergence of first tiller	Emergence of last tiller	Total duration of crop
Dates of planting	2681.67***	6907.6***	1019.44***
Error (a)	0.94	0.4	4.42
Mulches	11.67**	26.2***	1.40
DOP x Mulches	2.56	1.4	3.99***
Error	2.44	3.4	1.26

Dry matter accumulation at monthly interval

Sources of variation	Mean sum of squares				
	DF	1st	2nd	3rd	4th
Dates of planting	3	448869	1159987**	7595776**	30506751***
Error (a)	9	178961	126009	678520	714764
Mulches	3	86069	2892894***	11561809***	9475607***
DOP x Mulches	9	81500	258730*	3711875***	1375854***
Error	36	61651	95151	181221	282388

Appendix III (contd.)

Dry matter accumulation at monthly interval

Sources of variation	Mean sum of squares				
	DF	5th	6th	7th	8th
Dates of planting	3	147551095***	34392376***	52326603 **	41765126***
Error (a)	9	218040	1590585	3797777	1151338
Mulches	3	28050683***	22306220	15614952***	5936230***
DOP x Mulches	9	8466684***	1630931	576191*	167835
Error	36	527355	1119793	252383	275617

Yield and yield attributes

Sources of variation	Mean sum of squares									
	Yield (Kg ha^{-1})	Length of primary rhizome	Width of primary rhizome	Number of mother rhizome	Number of primary rhizome	Number of secondary rhizome	Weight of mother rhizome(g)	Weight of primary rhizome (g)	Weight of secondary rhizome (g)	Dry yield (kg)
Dates of planting	562370546***	44.411	0.41988***	1.63729	20.3492	286.971*	3953.5***	11711.1*	10745.7**	22531349***
Error (a)	23006222	47.012	0.01885	0.52729	11.6142	66.682	220.1	1772.1	1443.2	835871
Mulches	174315963***	16.627	0.00510	0.14896	7.2708	22.632	363.5	500.6	1483.2	7291374***
DOP x Mulches	18364760	34.227	0.02229	0.57785	10.5175	53.220	391.3	1250.5	647.8	723725
Error	10116620	22.954	0.02015	0.45174	7.7292	38.170	351.4	1035.7	789.0	355916

MICROMETEOROLOGICAL MODIFICATION WITH MULCHES TO ENHANCE THE YIELD OF TURMERIC (*Curcuma longa* L.)

By

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ABSTRACT OF THE THESIS

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Abstract

Turmeric (Curcuma longa L.) is one of the most important rhizomatous spices, belonging to Zingiberacea. It is an annual herbaceous plant native to tropical South-East Asia. Turmeric has high medicinal properties and it is wildly used in pharmaceutical, cosmetics and food industries. Due to the high value of the crop, it is getting good demand all over the world. India is one of the largest producer and consumer of turmeric around the world. In India turmeric is mainly planted in the hot summer months and grown as a rainfed crop, but due to the drastic changes in the agroclimatic conditions its production is influenced detrimentally. Mulching is an important cultural practice in turmeric, which helps to maintain an optimum microclimatic condition, reduce weed growth, add organic matter and conserve moisture throughout the high evaporative periods. Due to these changing climatic conditions assessment of an effective date of planting and finding a most suitable mulching practice are required for the effective production of turmeric. Hence, the goal of this study is to determine how planting dates and micrometeorological modifications with mulches affect turmeric yield.

Turmeric variety Kanthi was raised in Plantation Crops and Spices farm, College of Agriculture, KAU, Vellanikkara with four different dates of planting (1st May, 15th May, 1 st June and 15th June) and four different mulching treatments (white polythene mulch, black polythene mulch, paddy straw mulch and green leaf mulch). The experiment was laid out in split plot design with four dates of planting as main plot treatments and four mulching practices as subplot treatments. Crop weather analysis was done by using SPSS software and crop yield prediction model was developed with the help of Principal Component Analysis (PCA) and regression analysis.

The total crop period was divided into four phenophases (P1-planting to germination, P2-germination to initiation of active tillering, P3-initiation of active tillering to bulking, P4- bulking to physiological maturity). The days to reach each phenophases were different in every date of planting. May 1st planting took more days to reach 100 per cent germination and to reach physiological maturity both 1st

and 2nd dates of plantings took more time. The plant biometric characters like plant height, number of leaves, leaf area, number of tillers and dry matter accumulation were found to be more in earlier dates of planting (May 1st and May 15th) in almost all the time. In mulching practices paddy straw mulch was superior and it was followed by green leaf mulch. The yield produced by May 1st and May 15th dates of planting were on par and in case of mulching treatments paddy straw mulch produced superior yield than any other mulching practice.

In mulching treatments polythene mulches recorded more soil temperature and moisture content than organic mulches in almost all the time. The first phenophase of 1st date of planting recorded high maximum, minimum and soil temperature along with less rain fall and rainy days. This might have influenced the late emergence of turmeric. The increase in maximum temperature, wind speed, sunshine hours and evaporation reduced the plant height in third phenophase. Soil moisture content and relative humidity inside the plant canopy showed a positive correlation with yield, whereas soil temperature showed a negative correlation with yield during the bulking stage of turmeric. The decrease in maximum temperature, bright sunshine hours, wind speed and evaporation and the increase in the minimum temperature, forenoon and afternoon relative humidity and rainfall during bulking stage enhanced the yield in turmeric.

The development of yield prediction model with principal component analysis of mulching treatments and dates of planting of four phenophases were done and the yields of turmeric crop with these equations were predicted. This showed that, the predicted yield was in accordance with the observed yield in all mulching treatments.