European Journal of Agriculture and Food Sciences
www.ejfood.org

Effect of Plastic Mulch Color and Transplanting Stage on Baby Corn Plant Performance

Richard Kirigiah, Masinde Peter, and Mworia G. Erick

ABSTRACT

Different colored plastic mulches have been developed and used in various crop production methods. The main goals of using colored plastic mulches are to modify the radiation budget and reduce soil water loss. In addition, it aids in controlling weed and insect infestation as well as soil temperature, water use effectiveness, plant development, yield, and quality. The growth and development of baby corn depend on several geographical and climatic conditions in its surrounding (air and soil). This study determined the effect of different colored plastic mulches on soil temperature and the performance of two baby corn varieties (Pan 14 and Thai Gold). Black plastic mulches showed significantly higher soil temperatures, followed by transparent films, yellow films, and non-mulched, respectively. However, there were no significant changes in soil temperatures over the 17 weeks for specific plastic mulches. Pan 14 produced a higher yield and displayed improved vegetative growth compared to Thai Gold under similar conditions. Transparent plastic mulches showed the best yield and vegetative growth for both varieties but could not effectively control weeds. Black plastic mulches produced significantly higher yield and vegetative performance than non-mulched but were lower than the transparent film performance. Additionally, black plastic mulches showed better performance on weed minimization. The combined results indicated that the effect of colored plastic mulches is highly significant on soil temperature, moisture, and water-holding capacity. While black plastics increase soil temperature, transparent and yellow decrease it.

Keywords: Babycorn, Growth, Yield, Mulching, Plastic Mulch, Mulch Color, Silking, Transplanting.

Submitted: September 02, 2021
Published: October 20, 2021
ISSN: 2684-1827
DOI: 10.24018/ejfood.2022.4.5.567

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I. INTRODUCTION

Mulches are materials that are applied to the soil's surface for a variety of functions. Conversely, different colored plastic mulches have been made and used in various crop production methods [1], [2]. The main goals of using colored plastic mulches are to change the radiation budget and reduce soil water loss [3]. In addition, it aids in controlling weed and insect infestation as well as soil temperature, water use efficiency, plant development, yield, and quality [4]. The mulches used in farming systems come in a variety of types and qualities. The most popular mulches are made of gravel, pebbles, polyethylene film, organic materials like straw, hyacinth, wood, or leaves that can be used alone or in mixes, or living elements like turf grass, rye, and clover [5]–[7]. In underdeveloped nations, organic mulches, primarily organic straws, are most frequently used. However, organic mulches decompose, are less efficient, require more work, and are weather dependent [8]. The use of polyethylene (PE) as a plastic mulch for vegetable crop production in the 1950s after its discovery as a plastic film in 1938 significantly improved commercial crop productivity [9]. In the year 2018, 360 million tons of plastic mulch were produced globally, with the following distribution: 51% in Asia, 17% in Europe, 18% in NAFTA, 7% in Africa, 3% in the Commonwealth of Independent States, and 4% in Latin America [10], [11]. However, 4% or fewer of all plastics produced are utilized in agriculture for a variety of purposes, including mulching [10].

The farming community has used a variety of polyethylene colored plastic mulches with various formulas for various purposes. Previously, vegetable cultivation employed black, clear, and white plastic mulches. Today's most popular plastic colors include black, white, green, brown, red, silver, and blue. These colors were created taking into account how they affect plant physiology and light absorption. Numerous researchers have evaluated the effects of these colored plastic mulches on various crops [12]–[15].

The most widely used and widely available plastic mulch is black. The black mulch effectively absorbs solar radiation from the sun's ultraviolet, visible, and infrared wavelengths. By absorbing a significant amount of radiation, it significantly increased soil heat. The black plastic mulch is the opposite of the white variety. It reduces soil heating requirements for crops by cooling the soil [16], [17]. Plastic mulches come in a variety of colors to change the microclimate at the soil and plant levels. The spectral balance, quality, and quantity of light are all impacted by the color of plastic mulch, and this has an impact on several aspects of plant growth and development, including plant yield [18], [19].

By altering the radiation budget and reducing soil water loss, plastic mulches also have a direct impact on the microclimate in the area around the plant. By raising fruit quality, gross yield, and early production, improves crop productivity [20]. Additionally colored plastic mulches significantly affected soil water loss, soil temperature, plant morphology, and weed control [20]. The aim of color variation is to influence FR: R (far-red to red) ratios, which regulate phytochrome absorption and reflection. Thus, increased plant height and above-ground biomass are the reactions of plants receiving high FR: R light [21].

Black, white, and transparent plastic mulches are the three primary colors of colored plastic mulches used around the world for various crops. Black plastic mulch is utilized to absorb more light and heat, white mulch to reflect, and transparent mulch to generate intense heat [22]–[24]. Various plastic mulches have been produced recently in a variety of colors and compositions. These colored plastic mulches are utilized in various plant cropping systems for a variety of objectives. Different colored plastic mulches have different effects on crop yield, according to research studies. Their level of impact extends to crop output and quality, as well as the soil and water.

Considerably, soil characteristics are greatly affected by every method or technology application designed to encourage plant growth and development. These technical inputs had an impact on the soil's physical, chemical, and biological characteristics. One of the primary characteristics of soil that influences crop production is soil temperature. Numerous authors assert that a range of processes and activities, including nutrient uptake, water absorption, root growth, and the presence of soil microbes, are impacted by soil temperature [25], [26].

Soil temperature is significantly changed by colored plastic mulch. According to [1], [27], colored plastic mulches raised the soil's temperature above that of bare soil. The effect that colored plastic mulches have been observed to have on soil temperature by various researchers varies from region to region and from crop to crop. According to a research report by [1], [28], black plastic mulches recorded greater temperatures than olive, silver, white, and blue mulches. However, according to [29], the soil temperature was higher under the brown and blue plastic mulches than it was under the black and other mulches. This variation will result from differences in the soil types and local climates. Reports confirming this stated that black plastic mulch is more effective than white/black or aluminum/black plastic mulching systems in raising the minimum, maximum, and mean soil temperature [30]–[33].

Maize (Zea mays L.) is the third most widely cultivated cereal crop worldwide, behind rice and wheat [34], [35]. Among the cereals, it has the highest production potential and a wide range of industrial applications in addition to being used as food and animal feed. The United States Department of Agriculture (USDA) forecasts that 1,133.89 million metric tons of maize will be produced globally in 2021, with Serbia generating approximately 8,000,000 metric tons and ranking 16th in that category [36]. Baby corn is defined as immature, dehusked maize ears that have undergone two to four days of emergence before fertilization and harvesting [37], [38]. It is used to prepare various traditional and intercontinental dishes, besides being canned. The immature, unfertilized ears of baby corn, a kind of corn widely used by horticultural farmers around the world [39], are harvested within two to three days of the silk emergence [39]. After seeding, it begins the reproductive phase within 45-55 days and finishes the cycle in 60–70 days [40], [41]. When the ears are 5–10 cm long and 0.8–1.6 cm in diameter at the base or butt-end, they are ready for use [41]. To grow baby corn, either direct seeding or transplanting is possible. Many high-value vegetable crops are established by the use of transplants [42]. The best time to transplant seedlings depends on a number of growth parameters, including soil moisture, nutrients, temperature, light, and cultural techniques [43]. Among them, it has been demonstrated that temperature plays a significant role in determining the rate of plant growth, development, and production [44], [45].

To complete their growth cycles, plants need a particular amount of heat, measured in "growing degree-days" (GDD) [34]. Plant flowering dates, harvest ripeness, and the interval between two developmental stages are all estimated using GDD [41], [46]. Additionally, it is known that temperature affects how quickly successive new leaves appear at the stem's apex [47].

The quantity of fruits, fruit weight, and the length of the harvest per plant for capsicum plants was found to be influenced by the age of the transplants [46]. Greater plant establishment, grain yield per cob, grain yield per unit area, plant height, and straw production were found in maize seedlings that were three weeks old [48]. Corn seedlings transferred after 14 and 21 days reached maturity 6 and 12 days earlier than corn planted directly [49]. According to [50] baby corn is majorly grown for the export market in Kenya. Poor germination, scanty rainfall, and soil temperature are some of the major limiting factors that affect the quality and production of baby corn for the premium market. However, mulching can control soil temperature [1], [51]. Small-scale farmers in Meru County, Kenya, have not adequately adopted plastic mulching. Thus, there is a need to develop a more precise transplanting stage suitable for optimal production given the wide range of 3–4 weeks transplanting age of maize seedlings. The overall objective of the research was to determine the effects of different colored plastic mulch films on soil temperature, growth, and yield of two varieties of baby corn (Pan 14 and Thai Gold).

A. Impact of color on the efficiency of plastic mulches

The effect of plastic films on the temperature of the soil and crop canopy microclimate relies on their thermal properties. These involve reflectivity, absorptivity, or transmittance depending on incoming solar radiation [13], [52]. Black plastic mulch accelerated canopy establishment and grain yield due to increased root zone soil temperature and conservation of soil water [53]. Advancements in material (plastics) science have resulted in the development of films with optical properties that are ideal for a specific crop in specific locations without compromising the soil temperature at the plant root for farmers [1].

The changes in root zone soil temperature influences root physiological processes like absorption of water & soil nutrients and translocation of essential nutrients, which influences shoot and root growth. Elevated soil temperatures quicken crop emergence and growth, making the plants achieve the desired population structures at early growth stages [13], [54]. As a result, it enhances the absorption of solar energy, thus enhancing crop yield [6]. For instance, cucumber crops grown under plastic mulch films matured 7 to 14 days earlier and increased yields by 2 to 3 times compared to those grown on bare soil [18].

The color of the plastic mulch film used for mulching the soil determines the performance of the radiant energy, thus impacting the microclimate around the cultivated plants [12], [18], [52]. The interaction between the quality of the light reflected by the surface of the plastic mulch film, the capacity for transmission of solar energy, and the increase in soil temperature determine the response of plants to the colored film. The different types and colors of plastic mulch have characteristic optical properties that change the levels of light radiation reaching the soil. Therefore, the soil temperature can be modified by changing the color of plastic mulch films in regions of substantially high or low temperatures, thus encouraging faster plant development [1]. Reckon that depending on the crop variety, geographical location, and season, different colors of plastic mulches create high root zone-temperature conditions that might damage the growth, compromising vegetables' yield. Plastic mulch includes but is not limited to transparent, black, red, white, and yellow, and the choice of color depends on the intended purpose of the mulch.

Black-colored plastic film is the most popular among growers worldwide [16]. Over an extended period, it has been the standard plastic mulch in vegetable production as it changes the plant's growing environment by increasing the root-zone soil temperature and holding more soil moisture compared to un-mulched soil [1], [18], [51], [53]. However, according to [27], black plastic mulch lowers the quality of reflected light compared to other colored mulches, like red and blue mulches. The spectral distribution of the light reflected by these red and blue mulches is better utilized for photosynthesis and photomorphogenesis [18], [55]. These colors (blue & red) change the quality of the light spectrum regarding the proportions of the red to far-red wavelengths and blue light which predominantly controls the photomorphogenesis mediated by the different photoreceptors like phytochrome [56].

Using black and transparent plastic mulch films causes an average temperature increase compared to un-mulched soil temperature. The significant increase in temperature leads to early germination and shorter growing seasons due to the increased growing degree days of the soil. The increased GDD at the beginning of a season increases the chances of success in production in several ways. For instance, it enables crops to be grown with lower risk and a higher likelihood of germination; increases the choices of crops that can be grown (for instance, those demanding a higher price and requiring longer, warmer growing seasons); provides crop produce when price and demand are high; and, provides the farmer with more choices as to when plants may be harvested [6], [13], [51], [57].

White plastic mulch film generates cooler soil temperatures than black plastic [58]. This color is preferable during hot/summer growing seasons in warmer regions compared to black as it provides cooler soil temperatures. On the other hand, clear mulch provides more significant net radiation under the mulch and is thus more effective in increasing soil temperature than opaque mulches [1]. It absorbs lower solar radiation but transmits 85% to 95% of this energy depending on the plastic mulch film's thickness and degree of opacity. In addition, the underside of the clear plastic mulch usually is covered with condensed water droplets. These water droplets are transparent to incoming short-wave radiation but opaque to outgoing long-wave infrared radiation. Therefore, much of the heat lost to the atmosphere from bare soil by infrared radiation is conserved by clear plastic mulch. The clear (transparent and translucent) mulches promote a relatively large net radiation at the soil surface, increasing soil heat flux hence, increasing the minimum and maximum soil temperature [59], [60]. Black, clear, and white colored plastic mulches have been the most popular in vegetable farming [1], [61].

II. Materials And Methods

A. Study Location

The research was conducted at Abothuguchi West Division, Meru Central sub-county of Meru County in Kenya (Latitude 00 01' and Longitude 360 37'). The field plots were established between January and June 2018 to evaluate the influence of different plastic mulch colors and transplanting stages on the production and growth of two baby corn varieties (Pan 14 and Thai Gold). The field plots were 2 m long and 2 m wide. The colored plastic mulches and plastic drip irrigation lines were applied simultaneously on raised beds (15 cm in height).

B. Study Design

The experimental plots were arranged in a split-split plot design according to a method described by [62], with three replications of each treatment. Each of the three replications represented a different block. Baby corn was direct seeded into the field in January 2018 and June 2018. Treatments consisted of three mulch colors: black (B.P.), yellow (Y.P.), and transparent (T.P.). Bare soil or non-mulched (N.M.) plots without plastic mulch were used as controls. Soil pots of size 10 cm by 15 cm were filled with soil and 10 g of DAP fertilizer.

Planting holes were made on the polythene mulch plastic sheets using a hot round metallic bar of 2 cm diameter at a spacing of 60 cm by 25 cm [63]. Then, the plastic mulches were installed in the field (on the same day), and baby corn seeds were direct seeded. One seed was planted in each hole on bare soil, mulched plots, and soil plots.

C. Data Collection

Data was collected from three randomly selected plants in each plot. The data collected included soil and air temperature, and vegetative and yield parameters. Vegetative parameters included flowering period, Growing Degree Days (GDD) stage, and height. The yield parameters included the number of harvestable cobs, crop length, base diameter, and fresh weight of the first cob. Soil temperatures were recorded using minimum and maximum thermometers and inserted to a depth of 3 cm in the soil. In comparison, air temperatures were measured by placing the same thermometer 50 cm above the ground. Both air and soil temperatures were recorded daily at 1.00 pm East African Time (EAT) during the entire baby corn growth period. Seedling transplanting was done after 200, 300, and 400 GDD. Direct seeding was taken as a control.

Using a meter rule, the plants' flowering heights were determined by measuring the distance from the second node to the flag leaf level. The maturity period (maturity GDD) was determined by counting the days from the planting date to the flowering date for directly planted plants. However, for transplanted plants, it was the number of days from the transplanting day to the flowering date. Cob length and diameter were determined using a digital Vernier Caliper (Model 500-196; Mitutoyo-Digimatic, Kanagawa, Japan). The cob weight was determined using a digital weighing scale (Model KSH, KST, Kaushik Scale Corporation, Delhi, India). All the yield parameters were obtained on cobs harvested two days after silking.

D. Data Analysis

All experiments were carried out in triplicates. Data analysis was conducted using Statistical Package for the Social Sciences (SPSS version 26). The means of triplicate values were subjected to analysis of variance (ANOVA) using descriptive statistics and post-hoc using Least Significant Difference (LSD) option to determine statistical differences at a 95% confidence level. The means were considered significantly different at $P \leq 0.05$.

III. Results And Discussion

A. Effect of Plastic Mulch Color on Soil and Air Temperature

The significant kinds of colored plastic mulches used to produce different crops and vegetables globally include black, white, and clear plastic mulches. According to [32], black plastic mulches are applied to enhance light and temperature absorption, white to reflect, and clear plastic mulches produce elevated amounts of heat. Table I shows the impact of black, transparent, yellow, and non-mulched on the air and soil temperature for about 17 weeks. According to this study, there were no significant changes in soil temperature for respective plastic mulches during the 17 weeks ($P>0.05$) (Table I). However, at week 1, the black plastic mulch contained soils of significantly higher temperatures that increased by 34.18%, transparent plastic mulches by 21.38%, and yellow plastic mulches by 9.97%.

At week 9, black plastic mulches also showed significantly higher soil temperatures of 29.71 °C compared to other plastic mulches and control (non-mulched) ($P<0.05$). Similarly, the transparent and yellow mulches came second and third based on the magnitude of temperatures at 25.0 °C and 22.93 °C (Table I). At the end of the 17th week, black plastic mulches still produced soils of significantly higher temperatures compared to other mulches ($P<0.05$). This study, therefore, established that black plastic mulches accumulated significantly higher heat than transparent, yellow, and non-mulched treatments. Consequently, transparent plastic mulches followed the black mulches while yellow became third, with soils of slightly higher temperatures than the control (non-mulched).

Several studies have also found similar trends using plastic mulches of different colors. For instance, [71] reported the same trend in soybean, with black recording the highest temperature of 29.9 °C, followed by transparent at 29.6 °C, while non-mulched treatment had the least at 29.0 °C (Table I). The black-colored plastic mulches also retained higher temperatures than bright-colored plastic mulches in studies conducted by [55], [72]. These trends could be because the black polythene cover absorbed and retained more heat than all other tested plastic mulches. In this study, transparent plastic mulches produced soils of significantly higher temperatures than the control but lower than black plastic mulches.

Contrary to these findings, [73] found that transparent mulch had a 9% higher soil temperature than black mulch. [74] also found similar results where transparent mulch increased the soil temperature by 0.5 °C compared to the black film mulch. Similarly, [75] reported a higher soil temperature of 35-36 °C compared to 32-33 °C in black film mulch. These variations could be attributed to the geographical and climatic attributes of where each experiment was conducted.

Black mulch warms the soil by absorbing light, which is then conducted to the underlying soil, as long as the plastic mulch is in close contact with the soil. Black mulch absorbs much of the U.V., visible and infrared wavelengths from incoming solar radiation and re-radiates the absorbed energy as thermal radiation or long-wavelength infrared radiation [12], [55], [69]. On the other hand, transparent plastic mulch film absorbs little solar radiation of 5% short-wave. It reflects 11% while transmitting 85% to 95%, depending on the material's thickness and degree of opacity [1]. These variations are due to the differences in reflection, absorption, and transmission of the solar energy of the colored plastic films. Lastly, the yellow plastic mulches produced soils of significantly lower temperatures compared to transparent and black plastic mulches. This variation could be attributed to the components of radiation balance, which is due to the effect of mulch on albedo, sensible heat flux, latent heat flux, and soil heat flux [12]. The differences in soil temperatures could also be further associated with the optical properties of the mulch material as each material had a different reflectivity and absorptivity [70].

TABLE I: Air and Soil Temperature as Influenced by Plastic Mulch Color During the Crop Growing Period

Plastic Mulch Color	1 Week	3 Weeks	6 Weeks	9 Weeks	12 Weeks	15 Weeks	17 Weeks
Black (^{O}C)	26.93^{a}	29.14^{a}	29.36^{a}	29.71^{a}	29.50^{a}	29.50^{a}	28.80^{a}
Transparent (^{O}C)	24.36^{b}	24.71^{b}	25.00^{b}	25.00^{b}	24.36^{b}	24.21^{b}	24.40^{b}
Yellow (^{O}C)	22.07^{c}	22.21^{c}	22.93^{c}	22.71^{c}	22.07^{c}	21.00^{c}	21.20^{c}
Non-Mulched (^{O}C)	20.07^{d}	20.14^{d}	20.93^{d}	20.86^{d}	19.79^{d}	19.29^{d}	19.40^{d}
Air (^{O}C)	17.43^{e}	17.71^{e}	18.29^{e}	19.43^{e}	15.79^{e}	16.00^{e}	15.80^{e}
LSD	0.21	0.75	0.31	0.08	0.10	0.19	0.09

Values are means (±SD) of three independent determinations. Mean values with different superscript letters (a and b) in a row for each sample are significantly different at $P \leq 0.05$.

Therefore, this study shows that Plastic mulch color affects the surface temperature of the mulch cover and consequently the underlying soil temperature, thus determining the degree of soil warming. It should be noted that results from different regions show variations concerning how soil temperature responds to different colors of plastic mulch. Hence, the soil temperature under specific mulch color depends on the time, climatic and geographical positions.

B. Influence of Plastic Mulch Color on Baby Corn Performance

Various crop factors determine baby corn's performance. According to [71], maturity period, flowering plant height, flowering GDD, cob length, cob diameter, number of marketable cobs and weight of the first cob are among the most preferred parameters that determine corn performance.

C. Maturity Period

Corn requires about 60-100 days to be ready for harvesting based on the variety and warm weather. Typically, corn is ready for harvest when ears turn dark green, silks turn brown, and kernels are soft and plump; squeeze a kernel, and the juice will be milky, not clear [72], [73]. In this study, Pan 14 under non-mulched conditions took a significantly more extended period (81.17 days) to mature than other treatments. However, there were no significant differences between the maturity period of black mulch (63.5 days) and transparent mulches for Pan 14 (66.25 days) ($P<0.05$) (Table II). This could mean that transparent mulch and black mulch has a similar impact on the maturity of Pan 14 Corn.

Pan 14 under control conditions took the most prolonged maturity period of 81.2 days compared to other treatments. The shortest maturity period, between 61-64 days, was recorded for Thai Gold and Pan 14 plants under Transparent and Black plastic mulch, respectively. However, Pan 14 under transparent plastic mulch had a significantly more extended maturity period of 66.3 days compared to black, with a maturity period of 63.5 days (Table II). Even though the Control and Yellow treatment had a similar maturity period of 74.3 days in Thai Gold, a significantly lower maturity period of 72.5 days was recorded under yellow compared to 81.2 days under control in Pan 14 variety. These findings agree with [74], who reported flowering age in Freesia alba plants was reduced by 25 days and 19 days under black and transparent plastic mulches compared to the non-mulched plants.

On the other hand, non-mulched and yellow mulched Thai Gold varieties matured almost simultaneously; 74.25 and 74.33 days, respectively. However, the maturity period for the yellow and non-mulched Thai Gold was significantly higher than the maturity period of Transparent and Black plastic mulch Thai Gold; 61.0 and 61.33 days, respectively ($P<0.05$) (Table II). Generally, mulching showed a significant impact on the maturity period by reducing the maturity period significantly compared to the non-mulched treatments for all the baby corn varieties. Black and transparent plastic mulches significantly reduced the maturity period for all varieties based on the maturity period. These findings are supported by [59], [60]. According to [14], black plastic mulches showed better performance by producing crops of higher heights within a comparatively shorter time than transparent mulches. However, [7] suggested that transparent mulches showed no significant impact on the maturity period compared to black plastic mulch but accumulated more heat that could be detrimental to the plant yield. For corn production, [75] suggests that plastic mulches could influence plant nutrient uptake as they provide a favorable environment for better root growth by increasing the soil temperature and conserving soil moisture by reducing soil water loss via evaporation.

D. Flowering height

Flowering is the process where plants produce flowers to reproduce. The optimum height for corn plants to produce flowers is about 1.9–2.5 meters [63]. Comparing the types of mulches, transparent, yellow, and black mulching produced corn plants with significantly higher heights compared to controls of each variety. Black plastic mulches produced baby corn of significantly higher height than non-mulched plants of the same variety. For instance, black plastic mulches produced cornflowers at 247.92 cm compared to the non-mulched flowering height of 207.25 cm for the Pan 14 variety.

Similarly, Black plastic mulched Pan 14 produced flowers at a significantly higher height of 224.58 cm compared to non-mulched Thai Gold at 162.17 cm (Table II). Therefore, black plastic mulches increased the flowering height for all the corn varieties (Pan 14 by 19.62% and Thai Gold by 38.5%). Hence, black plastic mulching showed a double effect in increasing Thai Gold corn flowering height compared to Pan 14.

Increased flowering height in black plastic mulched plants could result from enhanced availability of soil moisture and optimum soil and air temperature. Black plastic mulch has been reported to increase soil temperature, directly related to early flowering initiation, expansion, and increased cumulative number of flowers [76]–[78]. [79] also found similar trends of the increased flowering height of 157% in aster flowers under plastic mulch compared to non-mulched. In addition, [80] reported a 5% increase in the flowering height of tomato plants after using black and transparent plastic mulch compared to non-mulched.

TABLE II: IMPACT OF PLASTIC MULCH COLOR ON THE PERFORMANCE OF PAN 14 AND THAI GOLD CORN VARIETIES

Interaction	Maturity period (days)	Flowering Plant Height (cm)	Flowering GDD (Heat Units)	Cob Length (cm)	Cob Diameter (cm)	No. of marketable cobs	Weight of first cob (g)
Non-mulched × Pan 14	$81.17^{d}\pm3.38$	$207.25^{a}\pm5.24$	$845.42^{a}\pm21.16$	$13.41^{a}\pm1.05$	$2.50^{c}\pm0.83$	$2.83^{bc}\pm0.58$	$128.75^{b}\pm9.72$
Yellow × Pan 14	$72.53^{bc}\pm5.38$	$242.25^{b}\pm4.39$	$921.08^{b}\pm20.13$	$13.65^{a}\pm0.89$	$2.67^{c}\pm1.02$	$3.0^{bc}\pm0.60$	$147.75^{bc}\pm6.54$
Transparent × Pan 14	$66.25^{ac}\pm2.63$	$242.92^{b}\pm4.98$	$943.33^{b}\pm21.11$	$14.19^{a}\pm2.16$	$3.62^{a}\pm0.57$	$4.17^{a}\pm0.2$	$169.83^{c}\pm7.64$
Black × Pan 14	$63.50^{a}\pm2.20$	$247.92^{b}\pm6.64$	$1172.08^{c}\pm36.32$	$14.06^{a}\pm1.79$	$3.19^{b}\pm0.94$	$3.75^{a}\pm0.62$	$123.42^{b}\pm6.35$
Non-mulched × Thai Gold	$74.25^{b}\pm3.22$	$162.17^{c}\pm5.81$	$771.83^{d}\pm13.23$	$12.4^{b}\pm0.16$	$2.59^{c}\pm0.62$	$2.17^{c}\pm0.58$	$70.17^{a}\pm4.93$
Yellow × Thai Gold	$74.33^{b}\pm3.03$	$198.00^{ac}\pm7.00$	$781.00^{d}\pm8.25$	$13.55^{a}\pm1.64$	$3.27^{b}\pm0.24$	$3.0^{ab}\pm0.60$	$62.50^{a}\pm6.78$
Transparent × Thai Gold	$61.0^{a}\pm2.99$	$216.0^{a}\pm7.06$	$841.25^{a}\pm8.72$	$14.12^{a}\pm1.66$	$3.65^{a}\pm0.89$	$3.92^{a}\pm0.52$	$75.58^{a}\pm4.85$
Black × Thai Gold	$61.33^{a}\pm2.74$	$224.58^{ab}\pm7.98$	$959.25^{b}\pm10.19$	$14.2^{a}\pm3.82$	$3.10^{b}\pm0.88$	$2.75^{bc}\pm0.62$	$64.67^{a}\pm6.893$

Values are means (±SD) of three independent determinations. Mean values with different superscript letters (a and b) in a column for each sample are significantly different at $P \leq 0.05$.

Generally, plants under plastic mulches showed superior plant height than the control, indicating that mulches positively affected plant growth and development. The light-colored mulches reflected elevated amounts of total light resulting in a lower ratio of far-red relative to red light. The increase in light intensity affects plant development and yield through more excellent photosynthetic rates. At the same time, the ratio of far-red to red (F.R.:R) ratio is important in phytochrome regulation of plant physiological processes which affect internodes lengths and stem elongation, chloroplast ultra-structure, photosynthetic efficiency, and photosynthate partitioning among leaves, stems and roots [1], [18], [52], [81].

E. Flowering GDD

Growing degree days (GDD) is the measure of heat accumulation used to predict plant and animal development rates involving the date a flower will bloom or a plant will reach maturity. Flowering GDD involves the amount of heat a plant uses before flowering. Mulching [82]. Considering the flowering GDD, Pan 14 variety established under black plastic mulch accumulated 1172 heat units while the same variety on the non-mulched condition recorded 845 GDD. Thai Gold variety under black and non-mulched conditions recorded 959 and 771 heat units, respectively. Apart from the yellow plastic mulch treatment in Thai Gold, all colored mulches significantly impacted the flowering GDD of various varieties. Black, transparent, and yellow treatments accumulated 38%, 12%, and 9% more heat units to flower than non-mulched in Pan 14 varieties. Thai Gold recorded the same trend of 24%, 9%, and 1% more heat units compared to the control. [64] also used soybean and found similar GDD trends using black, transparent, and non-mulched conditions citing that mulch color influences both long-wave radiation, short-wave reflection, and total radiant energy and latent heat flux, which in turn leads to the significant effect on soil hydro-thermal characteristics.

F. Cob Length and Diameter

According to [83], cobs involve the central core of an ear of corn where kernels grow. The size of corn cobs shows different corn varieties' overall performance [83], [84]. According to the findings of this study, non-mulched Pan 14 led to the production of corn with a length of 13.41 cm and a diameter of 2.5 cm. Using Pan 14, mulching using different colors of plastic bags did not significantly affect the length of cobs (P>0.05) (Table II). On the other hand, Transparent mulching produced Pan 14 and Thai Gold cobs with a significantly longer diameter (P<0.05) compared to control (non-mulched), yellow and black mulch for each respective corn variety. The yellow, transparent, and black plastic mulches increased the cob diameter of Pan 14 by 6.8%, 44.8%, and 27.6%, respectively. On the other hand, the yellow, transparent, and black plastic mulches increased the diameter of Thai Gold by 26.3%, 29%, and 19.7%, respectively. [74], also found similar trends by comparing black, transparent, silver, and green mulches. According to [51], transparent plastic mulching shows significantly improved results compared to black and yellow mulches in terms of cob sizes (length and diameter) as it is favorable for solarization that increases soil-surface temperature hence, enhancing the optimum conditions for corn growth. However, transparent mulching encourages weed growth and is less regarded for mulching than black plastic mulching [19].

G. Number of marketable cobs

Marketable cobs involve viable and fertilized corn that can be sold profitably. According to this study, transparent mulching showed a significantly higher number of marketable cobs for both corn varieties. The transparent mulch produced an average of 4.2 and 3.9 cobs in Pan 14 and Thai Gold, respectively. Control treatments (non-mulched conditions) produced the lowest number of marketable cobs (2.2 in Thai Gold & 2.8 in Pan 14). Other studies also found similar trends in the impact of mulching on the number of plant products. [85] reported a higher number of Squash fruits [27] under transparent mulching, followed by black mulching at 25, while control recorded the lowest at 17. On the contrary, some authors found that black mulching produced more plant products (fruits) compared to transparent and non-mulched treatments [65], [86].

H. Weight of the First Cob

The first cob involves the cob that is produced first after the flowering of corn. In most cases, the first cob matures earlier than the subsequent corn cobs [87]. In this study, mulching did not significantly affect the weight of the first cobs in the Thai Gold corn variety (P>0.05). However, mulching significantly impacted the weight of the first cobs in Pan 14 corn varieties (P<0.05). The weight of the first cobs of the Pan 14 corn variety increased by 14.8% and 31.9% for the yellow and transparent plastic mulches, respectively but decreased by 4.13% for black plastic mulches. Transparent plastic mulching produced the highest weight of corn cobs in both varieties; 169.83 g and 75.58 g, compared to the respective controls that produced corn cob of weight 128.75 g and 70.17 g for Pan 14 and Thai Gold, respectively. Therefore, transparent plastic mulch significantly affected the weight of corn cobs, especially for the Pan 14 variety. On the other hand, [63] reported 197.2 g and 125 g more fruit weight in Chilli under black and transparent, respectively, compared to the control. In strawberries, yellow plastic mulch led to the highest fruit weight of 19.06 g, followed by black at 16.98 g; non-mulch had 14.14 g [88]. In addition, [89] found that black plastic mulch produced corn cobs of significantly more weight on different crops.

IV. Conclusion

This study illustrates that corn variety and type of farming practices (mulching) significantly affect the performance of corn. The results indicate that hybrids and mulching treatments significantly influenced plant growth parameters like flowering period, plant height, and cob parameters of length, diameter, numbers, and weight. The difference between the hybrids (Pan 14 and Thai Gold) in flowering height, age and cob parameters is considerably associated with their genetic variability. However, the effect of plastic mulch colors on plant growth and cob parameters is highly associated with the microclimate conditions surrounding the plant, involving an increase in soil temperature, moisture retention, and reflected light rays. Plants grown on transparent plastic mulch had better vegetative growth and production than black plastic mulch film or un-mulched conditions. However, there were elevated weeds as the transparent film could have also enhanced weed growth. Therefore, this study recommends black plastic mulches, especially where weed management could be a major concern. The performance of black film mulch in terms of increased yield and weed suppression was much better than other colored plastic mulches under chilli production. The results above help us conclude that baby corn varieties' reproductive and vegetative traits were improved significantly by applying plastic mulches to transplanted plants. Clear and black-colored plastic mulch films improved the performance under field conditions. Additionally, complete inhibition of weed growth was observed under black plastic mulch, which could have helped boost baby corn production under transplanting.

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