



# Effect of Mulching as a Weed Management Strategy in Field Production of French Beans (*Phaseolus vulgaris* L) in Western Kenya

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## Authors' contributions

This work was carried out in collaboration among all authors. Authors may use the following wordings for this section: Author CA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AE, NL managed the analyses of the study. Author CA managed the literature searches. All authors read and approved the final manuscript.

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## ABSTRACT

There has been a 2% decrease on French bean (*Phaseolus vulgaris* L) production in Kenya due to factors such as weeds, pests and diseases and the challenge of controlling them using chemicals that result in high rejection rate or interception in the export market because of chemical residues. The objectives of this study were to evaluate the effect of different mulching materials on the growth and yield of French bean cultivars and to determine the effect of different mulching materials on weed density. Field experiments were carried out at KALRO Kitale, Trans Nzoia county Kenya. Season 1 was carried out during long rains of April and June 2021 and season two during the short rains of August and October 2021. Black polythene and grass mulch were compared with two hand

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weedings and no weeding in a Randomized Complete Block Design experiment with three replications. Data on growth and yield of French Beans were collected and subjected to ANOVA using GenStat to determine the significant differences between the treatments. The means were separated using Fisher's Unprotected LSD at 5% significance level. Growth and yield of French Beans was significantly influenced by the treatments ( $p \leq 0.05$ ). Plants grown under black polythene and grass mulch had the tallest height and the highest number of leaves and branches as well as number of pods and cumulative pod yield as compared to those that were hand weeded and unweeded. The highest yield of 2138 and 2597 kg/ha was obtained under black polythene mulch in season 1 and 2 respectively. This was significantly higher than that obtained from grass mulch, hand weeding and unweeding. In conclusion polythene and grass mulch improved growth and yield of French beans and reduced weed density. It is therefore recommended that farmers should adapt mulching as a cultural weed management strategy.

**Keywords:** French beans (*Phaseolus vulgaris* L.); polythene mulch; grass mulch; hand weeding.

## 1. INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an herbaceous plant in the family Fabaceae which originated in the Central and South America. It is an annual plant, with either a dwarf or climbing growth habit however the dwarf type is common in Kenya. It has long pods that vary in color, depending on cultivar with 3-12 seeds in its interior that may be black, white or red colored, two colored or marble [1]. It is commonly referred to as Snap beans, bush beans or string beans [2]. French beans are used as vegetables in stir-fry, stews and grilled-salad. In Asian region, French beans are used in curries, soups, stir-fry with rice etc. The leaves are also used as pot-herbs and the straws as forage. French bean productivity is highly dependent on factors such as cultivar, seed quality, fertilizer and proper cultural and management practices [3].

Weeds account for 45% of losses experienced annually on agricultural produce [4]. It has been estimated that weeds alone can reduce the yield of French beans by up to 20-60 per cent [5,6]. French beans are extremely poor competitors against weeds in field conditions and is highly susceptible to weed competition that affects the quality and ultimate yield and therefore should always be kept weed free [7]. Use of Hand weeding for weed control in French bean is quite effective but costly and time consuming whereas the use of chemical weed control is expensive and limited due to high market demand for chemical free produce [8]. Cultural weed management strategies such as mulching is therefore a promising option for weed control in French bean production systems. Mulching is a cultural crop management practice that involves covering the soil surface around plants with organic or inorganic materials that create favorable environment to help prevent growth

and establishment of weeds, suppress weeds that have emerged, conserve soil moisture, protect the soil from being eroded and maximize biological activities in the soil thereby improving crop production, fostering plant growth, and reducing water usage [9]. Organic mulching materials are those derived from plant and animal matter. They include residues and materials such as straw, hay, grass, compost, sawdust, wood chips and animal manures [10] while inorganic mulches are derived from synthetic materials such as polythene, landscape fabrics and woven polypropylene [11]. Polythene mulch account for the greatest volume of inorganic mulch used in commercial vegetable production and its use is slowly being adopted by small-scale farmers in vegetable production [12]. Polythene mulch may be transparent, black, red, yellow or other colors depending on the purpose of the mulch [13]. Black Polythene mulch is highly recommended for use in high value vegetable crops [14] as it controls most weeds and warms the soil, moderates soil temperature and conserves soil moisture enhancing crop maturity and in turn increasing total yields and significantly reducing losses caused by weeds [15]. A good mulch layer can save many hours and cost of laborious weeding and increase crop productivity [16,17,18,10]. The objectives of this study were to evaluate the effect of different mulching materials on the growth and yield of French bean cultivars and to determine the effect of the different mulching materials on weed density.

## 2. MATERIALS AND METHODS

### 2.1 The Experimental Site

The field experiments were conducted in two seasons at the KALRO Food Crops Research

Institute- Kitale in Trans- Nzoia County in Kenya under prevailing field conditions with Season 1 was carried out during long rains of April and June 2021 and season two during the short rains of August and October 2021. The demonstration farm lies on latitude 1°0'N and longitude 35°7'E at an altitude of 1900 m above sea level with mean temperature of 24 ° C and an average annual rainfall of 1300 mm.

## 2.2 Experimental Layout

The experiment was laid out in a Randomized Complete Block Design (RCBD), each block consisted of four plots measuring 2.1 m x1.5 m and were separated by 0.5 m paths. Four treatments were replicated three times. The treatments consisted of Black polythene mulch applied at a thickness of 30 µm to the plot before sowing and making holes at the points where seeds are to be planted, grass mulch applied to a thickness of 35 cm immediately after crop emergence and unmulched check.

## 2.3 Crop Husbandry

Certified seeds of French beans variety *Serengeti* were acquired from Royal Seed Company and sown at the recommended seed rate of 25 kg per ha, in the experimental sub plots at a spacing of 30 cm by 30 cm. Diammonium Phosphate (DAP) fertilizer was applied along the rows and mixed well with the soil before placing the seeds during sowing at a rate of 200 kg/ha. Calcium ammonium nitrate (CAN), was used as a top dressing at the rate of 150 kg/ha applied twice. First application was done when 2-3 leaves had appeared and the second at the beginning of flowering. Pest and disease management was done as per French bean production requirements. Black polythene and grass mulch were laid as treatments on the designated plots immediately after emergence at a thickness of 0.30 µm and 35 cm respectively. The black polythene mulch was cut into sizes that correspond to the plots and holes 5 cm cut on the polythene sheet for the protruding seedlings.

## 2.4 Data collection

Harvesting of French bean pods started six weeks after planting and continued for 3 weeks. The pods were harvested twice every week. Data was collected weekly beginning 4 weeks after emergence on the following: Plant height, Number of branches, Number of leaves per

plant, Cumulative number of pods per plant and cumulative pod yield. The data collected was subjected to analysis of variance (ANOVA) using GenStat Version 12.5 computer statistical and data management package. The treatment means were separated using the LSD Test and comparison done at probability  $p \leq 0.05$ .

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Mulch on Plant Height of French Beans

There was a significant difference in plant height on French beans grown under black polythene mulch, grass mulch, hand weeded and unweeded check at 4 and 5 weeks after emergence in season 1 ( $p \geq 0.05$ ) (Fig. 1a) and at 4,5,6 and 7 weeks after emergence in season 2 (Fig. 1b). However, at 6 and 7 weeks after emergence in season 1 there was no significant difference in plant height between hand weeding and unweeded and between grass mulch and polythene mulch (Fig. 1a). Polythene mulch performed the best as compared to grass mulch, hand weeded and unweeded check in both season 1 and 2, producing the tallest plants at 53.3 and 56.3 cm tall in season 1 and 2 respectively. This was closely followed by grass mulch at 52.0 and 50.2 cm tall in season 1 and 2 respectively. Unweeded check produced the shortest plants at 44.0 and 43.3 cm in season 1 and 2 respectively. Hand weeding which is farmers' common practice produced 44.0 and 45.2 cm tall plants in season 1 and 2 respectively (Fig. 1a, 2b). The difference in plant height could have been due to the different environmental conditions created by the mulches during the growth period. The tall plants produced by polythene mulch can be attributed to the fact that black polythene mulch conserves moisture better and increase soil temperature which provides favorable growth conditions for the plants. The short plants in the unweeded plots could be attributed to competition between the plants and weeds for nutrients that aid in the growth and development processes in plants [19]. Similar results were reported by Bhandari on broccoli [20] and Prakash in cucumber [21].

### 3.2 Effect of Mulch on Number of Branches per Plant of French Bean

Effect of the different mulching regimes on the number of branches per plant is shown in Figs. 2a and 2b.

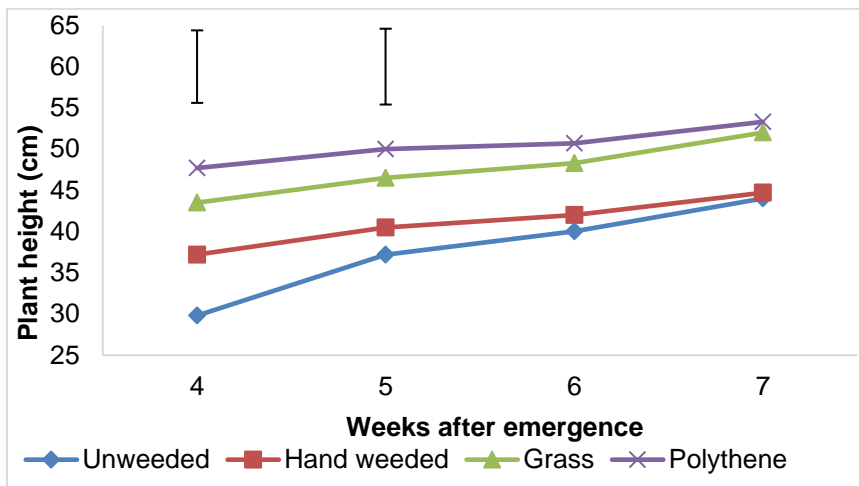


Fig. 1a. Effect of mulch on plant height (cm) of french beans in season 1 (\*vertical bars represent LSD bars at  $p = 0.05$ )

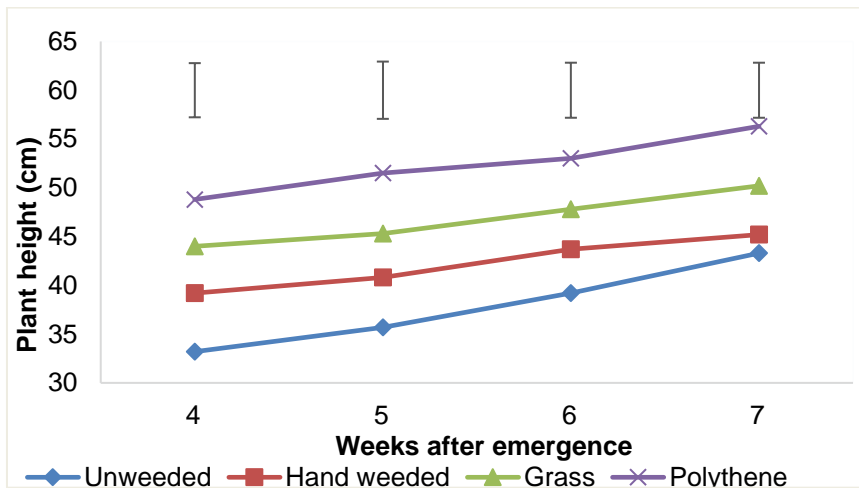


Fig. 1b. Effect of mulch on plant height (cm) of french beans in season 2 (\*vertical bars represent LSD bars at  $p = 0.05$ )

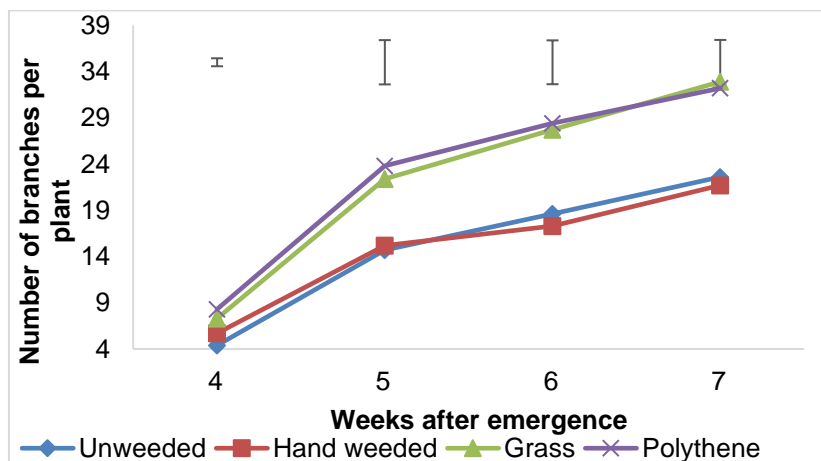
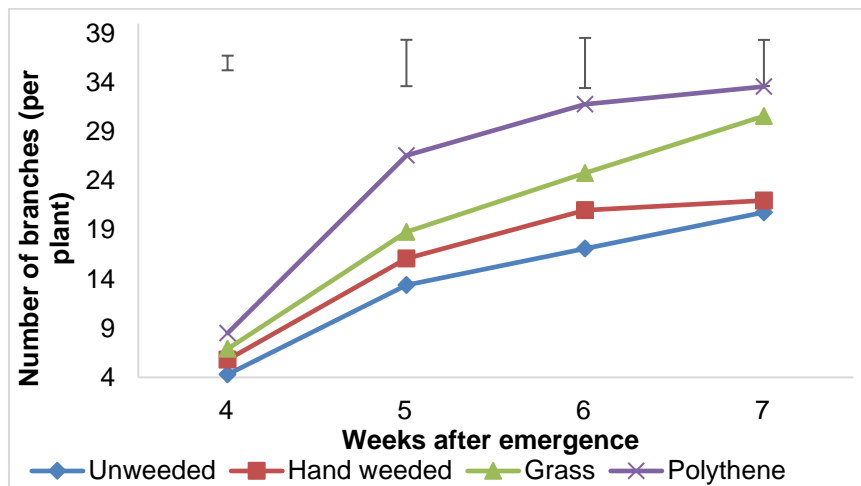


Fig. 2a. Effect of mulch on number of branches per plant in season 1 (\*vertical bars represent LSD bars at  $p = 0.05$ )



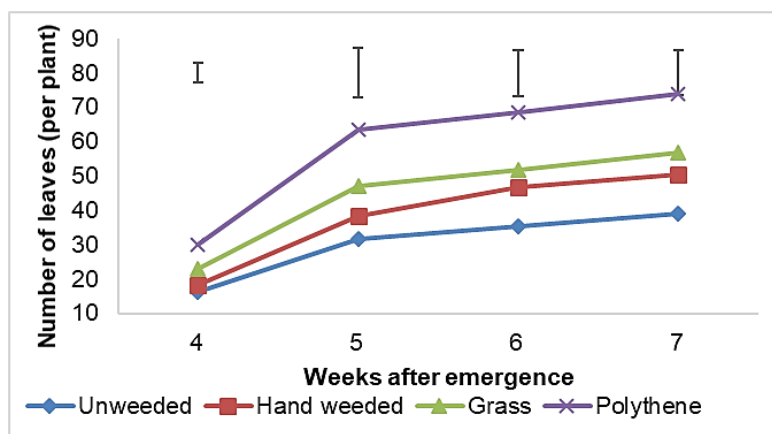
**Fig. 2b. Effect of mulch on number of branches per plant in season 2 (\*vertical bars represent LSD bars at p = 0.05)**

Mulching had a significant effect on the number of branches per plant throughout the experiment in both season 1 and 2 (Figs. 2a, 2b). There was a significant difference between mulching with black polythene or grass mulch as compared to hand weeding and unweeded check at 4, 5, 6 and 7 weeks in season 1, while in season 2 there was a significant difference in number of branches per plant for black polythene mulch, grass mulch, hand weeding and unweeded check at 5 and 6 weeks. However, there was no significant difference between hand weeding and unweeded check at 7 weeks after emergence in season 2. In both season 1 and 2, mulching with black polythene or grass increased the number of branches per plant significantly as compared to hand weeded and unweeded check. The different trends in the number of branches in season 1 and 2 can be attributed to the fact that Season 1 was a long rain season while season 2

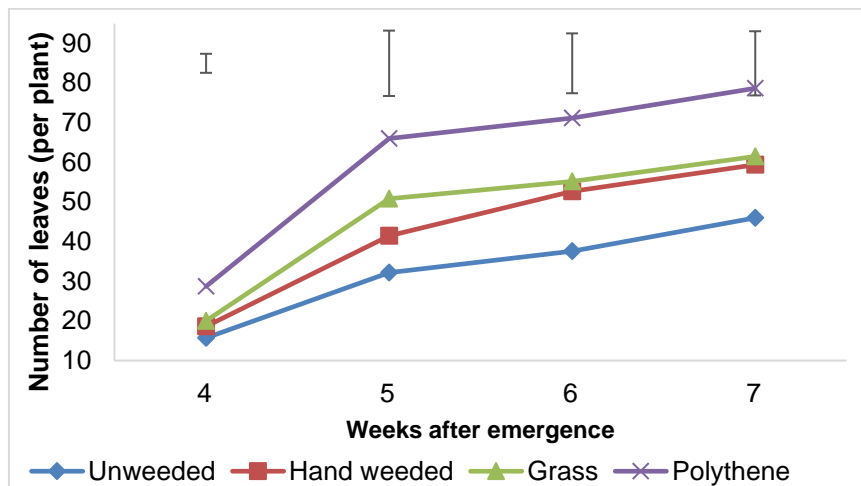
was short rain season. Polythene mulch produced plants with the highest number of branches while those that were in the control plot had the least throughout season 1 and 2 (Figs. 2a,2b).The high number of branches on the plots mulched with polythene and grass could be due to the favorable microclimate created by mulch that increase the growth and development process of the plants that organic and inorganic mulching increased plant height and number of branches [22].These results were in agreement with those obtained by Ashrafuzzaman et al [23] in Chilli and Ramesh (2021) in French beans.

### 3.3 Effect of Mulch on Number of Leaves per Plant

Effect of mulch on number of leaves per plant is shown in Figs. 3a and 3b below.



**Fig. 3a. Effect of mulch on number of leaves per plant in season 1 (\*vertical bars represent LSD bars at p = 0.05)**



**Fig. 3b. Effect of mulch on number of leaves per plant in season 2 (\*vertical bars represent LSD bars at p = 0.05)**

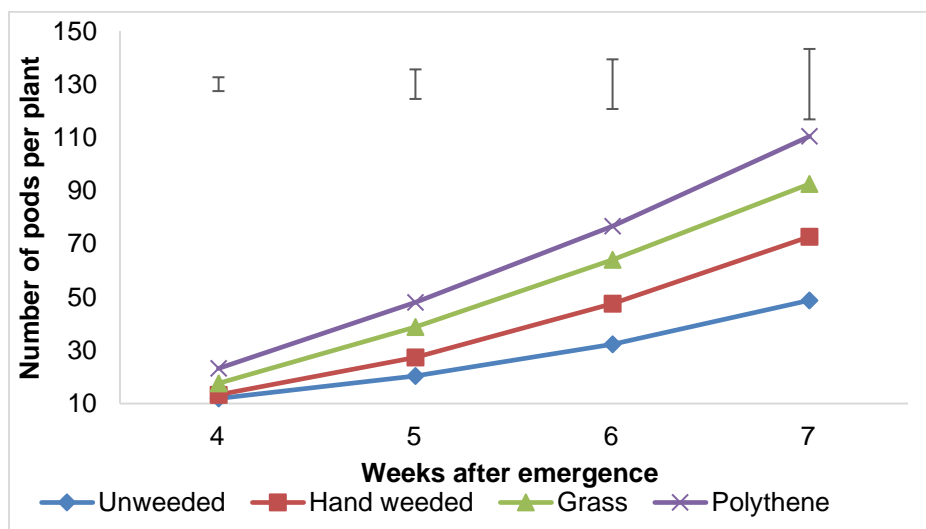
Effect of the different mulching regimes on number of leaves per plant was significant at 4, 5, 6 and 7 weeks after emergence in both season 1 and 2 (Figs. 3a, 3b).

The effect of polythene mulch on number of leaves per plant was highly significant as compared to grass mulch, Hand weeding and unweeded control throughout season 1 and season 2. Polythene mulch produced French beans with the highest number of leaves per plant throughout season 1 and 2 at 73.8 and 78.7 respectively 7 weeks after emergence, while unweeded check produced plants with the lowest number of leaves per plant throughout season 1 and 2 at 32.9 and 46.0 respectively 7 weeks after

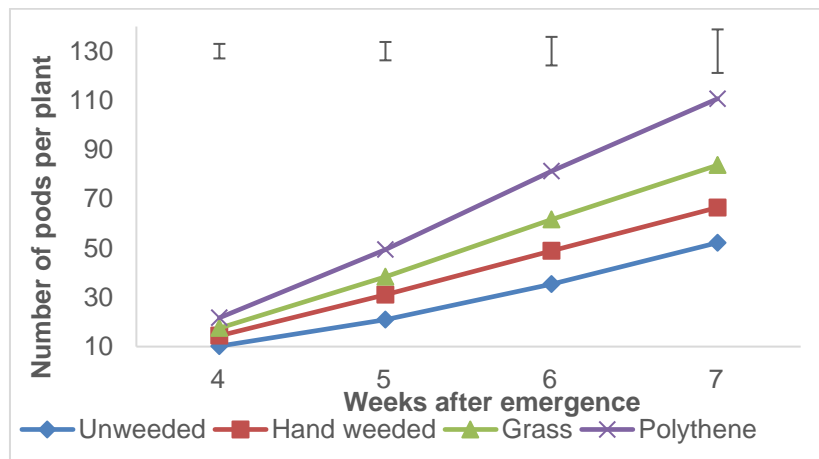
emergence (Figs. 3a, 3b). Similar results were reported by Chi Christopher et al [2] on Effect of Different Mulching Materials on the Growth and Yield of Green Beans (*Phaseolus vulgaris L.*) in Nfonta the Western Highlands of Cameroon. The microclimate condition improved by the mulches might have provided a suitable condition for producing higher number of leaves in the plants [23].

### 3.4 Effect of Mulch on Cumulative Number of Pods per Plant

Effect of mulch on cumulative number of pods per plant is shown in Figs. 4a and 4b below.



**Fig. 4a. Effect of mulch on cumulative number of pods per plant in season 1 (\*vertical bars represent LSD bars at p = 0.05)**



**Fig. 4b. Effect of mulch on cumulative number of pods per plant in season 1 (\*Vertical bars represent LSD bars)**

The different mulching regimes had different effects on the number of pods per plant. The effect of mulch on the number of pods per plant was significant ( $p \geq 0.01$ ) in season 1 (Fig. 4a) and in season 2 (Fig. 4b). Polythene mulch differed significantly from unweeded check in both season 1 and 2. Polythene mulch produced plants with the highest number of pods per plant throughout season 1 and 2. Number of pods produced by plants that were hand weeded and those that were not mulched did not differ significantly.

Mulching produced higher number of pod per plant and pod (yield per hectare) than control, indicating that mulch had positive effect in generating increased pod yield. The increase in the number of pods per plant of mulched plots was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface. This suitable condition enhanced the plant growth and development and produced increased pod bearing nodes compared to the control [23]. A previous study on the effect of different mulching materials on growth and yield of green beans (*Phaseolus vulgaris* L.), indicated a significant difference in pod yield per plant due to the favorable growth and development conditions created by mulch [2]. Higher number of pods per plant was obtained from black polythene mulch while those that were grown in control had the least number of pods per plant [24].

### 3.5 Effect of Mulch on Cumulative Pod Yield

The data on the effect of mulch on yield of French beans showed that there was a

significant difference in the pod yield in both season 1 and 2 ( $p \leq 0.001$ ). The highest pod yield in season 1 and 2 was from polythene mulched plots that had 2138 and 2598 kg/ha respectively. Grass mulched, hand weeded and unweeded check followed with 1582, 1171 and 888 kg/ha respectively in season 1 and 1934, 1419 and 953 kg/hectare respectively in season 2 (Table 1). Higher yields in mulch treatments might be due to its effects on soil temperature, soil moisture and weed suppression.

The significant difference in yield between the mulched and non-mulched plots can be attributed to the fact that mulching improves crop stands and increases yield as it provides favorable microclimate for optimum plant growth [25,26,16,] and improves soil properties by moderating soil temperature, reducing rate of evaporation, runoff and soil erosion [27,28].

### 3.6 Effect of Mulch on Weed Density

Effect of mulch on weed density in French beans was highly significant in season 1 and 2 ( $p \leq 0.001$ ). Polythene mulch, grass mulch, hand weeding and unweeded check all differed significantly in season 1. However hand weeding and grass mulch did not differ significantly in season 2. The highest weed density was that of unweeded check at 35.5 and 32.7 weeds per  $m^2$  in season 1 and 2 respectively, while the lowest weed density was that of polythene mulched plots at 10.0 and 8.8 weeds per  $m^2$  in season 1 and 2 respectively. This was followed by grass mulch and hand weeding with 14.5 and 23.5 weeds per  $m^2$  respectively in season 1 and 14.8 and 20.2 weeds per  $m^2$  respectively in season 2 (Table 2).

**Table 1. Effect of mulch on cumulative pod yield (kg/ha) in season 1 and 2**

Treatment	Season 1	Season 2
Unweeded check	888 d	953 d
Hand weeded check	1171 c	1419 c
Grass mulch	1582 b	1934 b
Polythene mulch	2138 a	2598 a
LSD <sub>0.05</sub>	113.8	262
CV (%)	6.4	12.3

*Means with the same letters within the rows or the columns are not significantly different at  $p \leq 0.05$*

**Table 2. Effect of mulch on weed density (number per sq. metre) in french beans in season 1**

Treatment	Season 1	Season 2
Unweeded check	36 a	33 a
Hand weeded check	24 b	20 b
Grass mulch	15 c	15 c
Polythene mulch	10 d	9 d
LSD <sub>0.05</sub>	2.7	6.0
CV (%)	10.3	25.0

*Means with the same letters within the rows or the columns are not significantly different at  $p \leq 0.05$*

The variation in weed density in the different mulch treatments was due to the fact that some treatments were more effective for weed control as compared to others. Similar research by Usman et al. [29] reported maximum weed density in control plots while the lowest density was found in mulched plots of Okra [29]. Weed control between mulched and non-mulched plots of eggplant also showed significant differences as reported by Ossom [30]. Low weed densities in plots mulched with grass and black polythene mulch can be attributed to the fact that mulching generally creates a physical barrier reducing the emergence, germination and growth of weed seeds keeping them in control [22] thereby reducing weed growth and in turn results in low weed densities. Black polythene mulch was the most effective mulch for weed control as it prevents penetration of light to the soil inhibiting weed seed germination and smothering emerged weeds [31].

Black plastic mulch suppressed the weed growth and thereby, increased the fruits yield [23], indicating black plastic mulch was more effective than the other mulches in suppressing weed growth. Black plastic mulch also blocked the weeds, except a few, which emerged through the planting holes (Schonbeck, 1998). Mukhtar et al. [32] reported that black plastic film mulch resulted in 100% control of all the weeds in maize that supported the present experimental result [32].

#### 4. CONCLUSION

Polythene mulch had the best growth any yield results and grass mulch performed the second best. Polythene and grass mulch had the lowest weed density as compared to hand weeding and unweeded plots. There was no significant difference between the cultivars

#### 5. FUTURE SCOPE

Farmers should be encouraged to adopt mulching as a cultural weed management practice so as to increase growth and yield of French beans. More varieties should be studied to determine the effect of mulch on their growth and yield.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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