World Journal of Agricultural Sciences 3 (6): 696-703, 2007
ISSN 1817-3047


# Influence of Mulch on Agronomic Characteristics, Soil Properties, Disease and Insect Pest Infestation of Dry Bean (*Phaseolus vulgaris* L.) In Swaziland

*E.M. Ossom and V.N. Matsenjwa*

Department of Crop Production, Faculty of Agriculture,
University of Swaziland, Private Bag Luyengo, Luyengo M205, Swaziland

**Abstract:** Dry bean (P*haseolus vulgaris* L.) is a grain legume that features prominently in Swazi cuisine. Information is lacking on the effects of mulch on agronomic characteristics and soil properties of dry bean in Swaziland. Therefore, a field experiment was conducted to assess the influence of mulch on agronomic characteristics, soil properties and yield of dry bean. Results showed that the longest pods per plant (mean, 8.61 cm) were obtained under newspaper mulch and the shortest pods (7.38 cm) were from the grass mulch. Unmulched plants had significantly ($P<0.05$) higher pod yield (3296.4 kg $ha^{-1}$) than plants under grass mulch (2263.2 kg $ha^{-1}$), newspaper mulch (2102.8 kg $ha^{-1}$) and clear plastic mulch (1826.0 kg $ha^{-1}$). There were no significant differences between unmulched plants and plants under black polythene mulch (2924.9 kg $ha^{-1}$). Mulch modified soil temperatures (means: Surface soil, 32.4°C; 5-cm depth, 28.4°C; 10-cm depth, 30.1°C). Unmulched plants had a significantly ($P<0.05$) higher seed yield (18813 kg $ha^{-1}$) than grass mulch (746.3 kg $ha^{-1}$); black polythene mulch (1562.8 kg $ha^{-1}$); clear plastic mulch (889.2 kg $ha^{-1}$) and newspaper mulch (959.7 kg $ha^{-1}$). Though mulch led to beneficial agronomic features, it did not significantly increase seed yield. No mulching, accompanied by timely weeding, is recommended.

**Key words:** Agronomic characteristics · dry bean · grain legume · *Phaseolus* · soil chemical properties

## INTRODUCTION

Dry bean (P*haseolus vulgaris* L.), also called field bean, is the most important grain legume in Swaziland, being followed by peanut (*Arachis hypogaea* L.). Dry beans are prepared separately as a relish or they are prepared with maize grains as a mixture. Though commonly eaten, dry beans are cultivated on a very small scale in Swaziland, but the crop is usually imported from South Africa, to meet the shortfall in local demand and consumption. Dry bean is the most important food legume of more than 500 million people in Latin America and Africa and for more than 100 million people, it is the leading source of dietary protein [1]. Beans are ranked among the major grain legumes in the world; they can be consumed as vegetables or grain legumes, being easy to cook and can also be used as green manure and as a good fodder crop [2]. Crop residues are often ploughed under in small-scale farming in Swaziland, but uninformed farmers typically burn, or feed crop residues to livestock, with the resultant loss of mineral nutrients, as there is no release of nutrients into the soil, in the long run [3]. One major group of activity in Swaziland is the development of appropriate agronomic technologies for each of the legume crops; the crops adaptability varies as per agro-ecological zone, and management practices also depend on the soil type and other elements [4].

In Swaziland, mulching has been practiced for many years, but it has been done mostly in the production of vegetable seedlings. To secure the future for grain legume production, it is important to perform practices that could provide greater yield per land holding. This could be beneficial, because animal protein, which is the substitute for plant protein, might not be readily available in the future. One reason for this could be that societies that protect animals from being killed for food could encourage different countries to promulgate laws, which could prevent humans from getting animal protein [5]. In addition to this, meat has been found to be associated with some diseases [5] such as mad cow disease, avian influenza, Severe Acute Respiratory Syndrome (SARS), endometriosis, colon cancer and prostate cancer. To

**Corresponding Author:** Prof. E.M. Ossom, Agronomist, Department of Crop Production, Faculty of Agriculture, University of Swaziland, Private Bag Luyengo, Luyengo M205, Swaziland

help improve the quality of the dietary protein in grain legumes in the developing countries, attention needs to be directed towards management practices concerned with crop production, which could lead to increased yield [6]. Grain legumes have had a favored position in agriculture and in the human diet. However, according to the overall figures, their situation in world agriculture is currently that of a group of crops clearly in regression: horticultural crops are prospering, but this is not the case with extensive crops and those specific to subsistence farming [7]. This situation affects all species of grain legumes, especially those produced in subsistence farming of many developing countries. In this type of agriculture, legumes may not play a very important role as regards quantities produced, but their value is high from the qualitative point of view, as they generally supply the scarce proteins available for human consumption [7]. It is not known how much contribution mulches make to nutrient releases in the soil, or to what extent mulches regulate soil temperature in dry bean production. Therefore, this field investigation was conducted with the following objectives: i.) assess agronomic characteristics and yield of dry bean, ii), determine how soil properties are influenced by mulch and iii) evaluate the influence of mulch on dry bean on disease and insect pest infestation.

## MATERIALS AND METHODS

**Location and experimental design:** The experiment was conducted in the 2005/2006 cropping season and sited in the Middleveld agro-ecological zone of Swaziland, at the Faculty of Agriculture, in Luyengo (26.3°S, 31.1°E; mean annual rainfall, 800 mm; 732.5 m above sea level; and mean annual temperature, 18°C). The soil was an Oxisol of the Malkerns soil series. The experimental design was a randomized complete block having five treatments: 1), No mulch (control) but weeded at 4 weeks after planting (WAP); 2), grass mulch (20,000 kg $ha^{-1}$, 10.0 cm thick); 3), Black polythene mulch; 4), clear plastic mulch and 5), newspaper mulch. Plastic mulches were 0.1 mm thick; and were applied at the rate of 772.0 kg $ha^{-1}$. All mulches were applied two weeks after crop emergence. Plot sizes were 4.0x4.0 m, with a 50-cm space between plots on all sides.

**Land preparation and planting:** The land was plowed and harrowed using tractor-mounted, moldboard ploughs and disc harrows, respectively. To keep all plots in a weed-free state, general weeding was done 1 week before planting. Compound fertilizer, N:P:K [2:3:2 (22)+0.5% Zinc] was applied at 400.0 kg $ha^{-1}$, just before planting, using the banding and incorporation method. At 4 WAP, limestone ammonium nitrate (LAN, 28% nitrogen) was also applied at 250.0 kg $ha^{-1}$ [8], using the dollop method. Planting (50.0 cm between rows and 10.0 cm within rows) was done on 5 November 2005, using 'PAN 159' variety, which was purchased from a reputable seed supplier, Etsala Seed Company in Malkerns, Swaziland. The initial planting rate was two seeds per stand, but these were thinned 1 week after emergence to attain the plant population of 200,000 plants $ha^{-1}$ [8]. Supplementary irrigation, using sprinklers, was applied every 3 weeks (for 2 months) till rains became regular; on each occasion, the soil was watered to field capacity.

**Data collection and analysis:** Data were collected on some agronomic characteristics, soil properties, as well as disease and insect pest infestation. Plant height was measured with a meter rule at 2-10 WAP. The number of pods per plant was taken from three plants per plot. A pod was regarded as a fruit, which was not less than four centimeters in length; pods shorter than four centimeters are usually of no commercial value. Pod length was measured using a 30.0-cm ruler. The seed yield was obtained at harvest (12 WAP). Soil moisture content was determined at 6, 8 and 10 WAP using the gravimetric method [9], the soil being dried at 105°C for 48 hours. Soil temperatures were measured at the soil surface, 5-cm depth and 10-cm depth, using the Fisherbrand bi-metal dial thermometers, between 1400 hrs and 1600 hrs on sunny, dry days [10]. Disease infestation on leaves was assessed within a 50.0-cm quadrat and a scale of 1-6 [10] was used for scoring for disease infestation. On this scale, the descriptions [10] were as follows: 1), complete absence (0%) of disease on all leaves; 2), disease present on 1-20% of all leaves; 3), disease present on 21-40% of all leaves; 4), disease present on 41-60% of all leaves; 5), disease present on 61-80% of all leaves; and 6), disease present on 81-100% of all leaves. The scoring was done in four determinations per plot. Five plants per plot were randomly selected for insect pest assessment. Insect pest infestation [11] was scored on a scale of 1-5, using visual population rate. On this scale, the descriptions [12] were as follows: 1), no insect pest infestation; 2), occasional individual insect pests on plants; 3), insect pests abundant, but plants not showing damage symptoms; 4), insect pests abundant and plants showing damage symptoms; and 5), severe insect pest infestation. A beating sheet and a sweeping net were used to trap insect pests. In order to obtain the relative pest numbers per plot, a 30-cm sweep net was swung through 180° [12, 13]. Data were analyzed with MSTAT-C (version 1.3) statistical software; mean comparisons were made using the F-protected least significant difference test [14] at P<0.05.

## RESULTS AND DISCUSSION

**The initial soil fertility status of the soil was as follows:** pH ($CaCl_2$), 4.8; organic matter, 2.91; P, 3 mg $kg^{-1}$; K, 0.19 cmol $kg^{-1}$; exchangeable acidity, 0.68 cmol $kg^{-1}$; Mg, 0.57 cmol $kg^{-1}$ and Ca, 0.01 cmol $kg^{-1}$. Thus, the soil was acidic in reaction and was of low nutrient element status.

**Agronomic characteristics:** Plant height: Table 1 shows the trend in plant height. Mulch increased the plant height in field bean, the unmulched dry beans being the shortest (mean height, 39.7 cm) and plants mulched with black polythene being the tallest (43.2 cm). There were significant differences among the mulch types only at 6 and 8 WAP. Correlation studies indicated that the relationship between plant height at 2 WAP and grain yield showed a positive correlation (r = 0.368; n = 20), indicating the coefficient of determination ($R^2$) to be 0.135, which implies that 13.5% of the variation in grain yield could be attributed to plant height at 2 WAP. At 4 WAP, the grain yield and plant height also showed a positive correlation (r = 0.032; n = 20), indicating $R^2$ to be 0.007, which implies 0.10% contribution of plant height to grain yield $ha^{-1}$ in dry beans. At 6 WAP, the correlation coefficient was negative (r =-0.125; n = 20), indicating 1.6% contribution of plant height to grain yield loss in dry beans. At 8 WAP, the correlation coefficient was also negative (r =-0.078; n = 20), giving $R^2$ of 0.006, which implies 0.6% contribution of plant height to reduced grain yield in dry beans. At 10 WAP, the correlation between grain yield and plant height showed that 0.5% of the variation in grain yield could be attributed to plant height.

It was reported [15] that under black polythene mulch, movement and leaching of nutrients were reduced and utilization by the bean crop was increased. Mulching prevented the impact of raindrops, reducing crusting and prevented compaction so that roots could explore for nutrients easily. However, the increase in plant height did not lead to a corresponding increase in the yield; probably the height increased at the expense of the plant. It was postulated [16] that some reduction in wheat plant height could improve yield substantially.

Table 1: Influence of mulch on plant height (cm) of dry beans from 2-10 weeks after planting

| | Weeks after planting | | | | | | |
|---|---|---|---|---|---|---|---|
| Mulch type | 2 | 4 | 6 | 8 | 10 | Total | Means |
| No mulch | 10.7 | 33.0 | 47.8 | 51.4 | 55.4 | 198.3 | 39.7 |
| Grass mulch | 10.1 | 33.4 | 55.5 | 61.1 | 54.5 | 214.5 | 42.9 |
| Black polythene mulch | 10.9 | 31.3 | 57.2 | 60.7 | 56.3 | 216.2 | 43.2 |
| Clear plastic mulch | 10.4 | 32.3 | 53.6 | 53.8 | 55.6 | 205.7 | 41.1 |
| Newspaper mulch | 10.9 | 32.2 | 52.4 | 50.6 | 54.4 | 200.4 | 40.1 |
| Mean | 10.6 | 32.4 | 53.3 | 55.5 | 55.2 | 207.0 | 41.4 |
| [1]$LSD_{(0.05)}$ | 1.40 | 3.68 | 8.04 | 6.84 | 4.22 | N/A | N/A |
| Significance | N/A | NS | * | * | NS | N/A | N/A |

* Significant at P<0.05;

NS, not significant; N/A, not applicable

[1]Least significant difference

Table 2: Influence of mulch on the number of pods per plant of dry bean from 8-10 WAP

| | Weeks after planting | | | |
|---|---|---|---|---|
| Mulch type | 8 | 10 | Total | Means |
| No mulch | 8.3 | 9.1 | 17.4 | 8.7 |
| Grass mulch | 9.3 | 8.7 | 17.9 | 9.0 |
| Black polythene mulch | 10.7 | 9.1 | 19.8 | 9.0 |
| Clear plastic mulch | 9.4 | 7.3 | 17.0 | 8.4 |
| Newspaper mulch | 7.5 | 7.2 | 14.7 | 7.3 |
| Mean | 9.0 | 8.3 | N/A | N/A |
| [1]$LSD_{(0.05)}$ | 3.20 | 2.18 | N/A | N/A |
| Significance | NS | NS | N/A | N/A |

NS, not significant; N/A, not applicable;

[1]Least significant difference

**Number of pods per plant:** Table 2 shows the effects of mulch on the number of pods per plant in dry beans. No pods were formed before 8 WAP. Though the number of pods per plant increased from 8-10 WAP, there were no significant differences among the mulching treatments. Black polythene mulch resulted in plants with the highest mean number of pods (9.9), followed by plants mulched with grass mulch (9.0). Plants mulched with newspapers had the lowest number (7.3) of pods per plant. It was established [17] that the number of pods per plant was a yield component that was most affected by drought stress. In soybean (*Glycine max* L.), it was observed [18] that increased number of pods per plant also increased soybean yield and there was a high correlation between seed yield and the number of pods per plant in soybean [18].

Table 3: Influence of mulch on pod length (cm) in dry beans

| Mulch type | Weeks after planting 8 | 10 | Total | Means |
|---|---|---|---|---|
| No mulch | 8.3 | 8.6 | 17.4 | 8.7 |
| Grass mulch | 6.3 | 8.4 | 17.9 | 9.0 |
| Black polythene mulch | 7.7 | 8.9 | 19.8 | 9.0 |
| Clear plastic mulch | 7.9 | 9.2 | 17.0 | 8.4 |
| Newspaper mulch | 8.4 | 8.9 | 14.7 | 7.3 |
| Mean | 7.7 | 8.8 | N/A | N/A |
| [1]LSD$_{(0.05)}$ | 1.56 | 0.72 | N/A | N/A |
| Significance | * | * | N/A | N/A |

*Significant at P<0.05; NS, not significant; N/A, not applicable;

[1]Least significant difference

Table 4: Correlation between seed yield of dry beans and selected parameters at eight weeks after planting

| Parameter | Seed yield: Slope | Correlation coefficient | Intercept |
|---|---|---|---|
| Soil moisture content | 12.734 | 0.192 | 633.41 |
| Insect pest score | 442.403 | 0.156 | 654.64 |
| Plant height | -6.161 | -0.078 | 1549.75 |
| Canopy width | 35.701 | 0.396 | -240.58 |
| Number of leaves per plant | 45.923 | 0.288 | 608.57 |
| Leaf area per plant | 0.329 | 0.183 | 929.69 |
| Number of pods per plant | 21.223 | 0.101 | 1016.27 |
| Fresh mass of pods per plant | 13.500 | 0.308 | 703.49 |
| Dry mass of pods per plant | 76.730 | 0.242 | 858.10 |
| Length of pods per plant | 157.646 | 0.376 | -8.76 |
| Pod dry matter | -24.958 | -0.332 | 1825.59 |

Table 5: Effects of mulch on the number of leaves per plant in dry bean at 2-10 weeks after planting

| Mulch type | Weeks after planting 2 | 4 | 6 | 8 | 10 | Total | Means |
|---|---|---|---|---|---|---|---|
| No mulch | 4.2 | 6.2 | 9.6 | 14.0 | 12.9 | 46.9 | 9.4 |
| Grass mulch | 4.1 | 6.6 | 10.8 | 14.2 | 13.0 | 48.6 | 9.7 |
| Black polythene mulch | 3.8 | 6.9 | 9.7 | 15.1 | 10.4 | 45.8 | 9.2 |
| Clear plastic mulch | 3.9 | 5.8 | 9.7 | 11.4 | 8.5 | 39.2 | 7.9 |
| Newspaper mulch | 3.8 | 6.7 | 9.6 | 10.5 | 11.9 | 42.4 | 8.5 |
| Mean | 4.0 | 6.4 | 9.8 | 13..1 | 11.3 | 44.6 | 8.9 |
| [1]LSD$_{(0.05)}$ | 0.46 | 0.72 | 2.44 | 4.34 | 4.37 | N/A | N/A |
| Significance | N/A | NS | NS | * | * | N/A | N/A |

*Significant at P<0.05;

NS, not significant; N/A, not applicable;

[1]Least significant difference

**Pod length:** The effects of mulch on pod length are shown in Table 3. At 8 and 10 WAP, mulch had a significant (P<0.05) influence on length of pods per plant. The longest pods were obtained under newspaper and clear plastic mulch (each with a mean length of 8.6 cm) and the shortest pods (7.4 cm) were from the grass mulch. Table 4 shows the correlation coefficients of some selected parameters of dry bean at 8 and 10 WAP.

Table 6: Influence of mulch on seed yield of dry bean

| Mulch type | Grain yield (kg ha$^{-1}$) |
|---|---|
| No mulch | 1881.3 |
| Grass mulch | 745.3 |
| Black polythene mulch | 1562.8 |
| Clear plastic mulch | 889.2 |
| Newspaper mulch | 959.7 |
| Mean | 1207.6 |
| [1]LSD$_{(0.05)}$ | 255.15 |
| Significance | NS |

[1]Least significant difference;

NS, not significant at P>0.05

**Number of leaves per plant:** Table 5 shows the influence of mulch on the number of leaves per plant in dry beans. The mean number of leaves was highest under grass mulch (9.7) and lowest (7.9) under clear plastic mulch. There were significant differences (P<0.05) at 8 and 10 WAP. A higher number of leaves generally implies that there could be a higher leaf area index and, therefore, a higher crop yield. It was earlier observed [19] that the best way of increasing yield was by increasing the leaf area index. However, as the number of leaves continued to increase, shading of lower leaves could result such that the shaded leaves could become parasitic and thus, might reduce the yield. The decrease in the number of leaves per plant in most treatments at 10 WAP, was a result of leaf senescence.

**Seed yield:** The seed yield is shown in Table 6. The unmulched dry beans had a significantly (P<0.05) higher seed yield (18813 kg ha$^{-1}$) than grass mulch (745.3 kg ha$^{-1}$). Other yields were: black polythene mulch (1562.8 kg ha$^{-1}$); clear plastic mulch (889.2 kg ha$^{-1}$) and newspaper mulch (959.7 kg ha$^{-1}$). Mulch increased the shelling percentage of dry bean: no mulch, 58.3%; grass mulch, 33.3%; black polythene, 54.6%; clear plastic, 48.3%; and newspaper mulch, 45.1%. So mulching could be used to increase the shelling percentage of dry bean. Black polythene mulch appeared effective in increasing shelling percentage.

That unmulched plants had greater yield could be because weeds were completely removed in the unmulched plots, whereas in the intra-rows of mulched plots, weeds competed with the crop, hence the low yields. The weeds in the mulched plots kept the soil

Table 7: Influence of mulch on soil moisture content (%) at 6-8 weeks after planting

| Mulch type | Weeks after planting 6 | 8 | 10 | Total | Means |
|---|---|---|---|---|---|
| No mulch | 10.5 | 17.1 | 10.2 | 37.8 | 12.6 |
| Grass mulch | 13.7 | 13.4 | 14.2 | 41.2 | 13.7 |
| Black polythene mulch | 12.0 | 14.2 | 10.5 | 36.7 | 12.2 |
| Clear plastic mulch | 12.5 | 15.8 | 12.2 | 40.4 | 13.5 |
| Newspaper mulch | 11.6 | 14.7 | 9.10 | 35.5 | 11.8 |
| Mean | 12.1 | 15.0 | 11.2 | N/A | N/A |
| LSD (0.05) | 4.79 | 3.72 | 3.62 | N/A | N/A |
| Significance | NS | NS | * | N/A | N/A |

[1]Least significant difference

surface moist, in addition to moisture from increased rain. Reduced photosynthesis due to shading of crop by weeds might have caused the low yields obtained under mulch. It was earlier reported [18] that increased photosynthesis resulted in higher seed yields in soybean. Some dry bean leaves were destroyed due to consistent wetting by rain and there was less biomass aboveground. Seed yield was shown to be highly correlated with the final aboveground biomass production [20].

**Soil properties:** Soil moisture content: Table 7 shows the influence of mulch on soil moisture content at 6-8 WAP. Grass mulch conserved the highest amount of moisture (13.7%) and newspaper mulch had the lowest (11.8%). Grass mulch had significantly ($P<0.05$) higher moisture content at 10 WAP than newspaper mulch (9.1%), the control (10.2%) and black polythene mulch (10.5%). Newspaper mulch decreased soil moisture content than the unmulched soil.

That grass mulch conserved more soil moisture could be probably due to the ability of grass to protect intense heating of the soil and, therefore, keeping the microclimate of the soil cool. It could also be because grass mulch, unlike the other mulches and the control, was able to increase the infiltration rate of rain or irrigation water, whereas in the other mulches, the water might not have properly infiltrated into the soil and the water could have been left on the surface of the mulch (as was observed in plastic mulches) and could have evaporated as the sun's heat increased. Grass mulch could also have absorbed dew in the early mornings and such moisture could move by diffusion gradient to the drier soil beneath.

The findings of this study were consistent with previous findings [3] in which it was shown that trash (such as grass mulch) improved the moisture regime of the soil. It was also previously shown that organic mulch could help to retain soil moisture, avoid or prevent soil desiccation and this might improve seedling survival [21]. It was explained [22] that improved plant performance was also attributable largely to improved water relations resulting from diminished soil surface evaporation and elimination of transpirational losses from competing vegetation.

Table 8: Influence of mulch on soil temperature (°C) of sugar bean soils

| Mulch type | Soil depth | Weeks after planting 2 | 4 | 6 | 8 | 10 | Mean |
|---|---|---|---|---|---|---|---|
| No mulch (control) | Surface | 30.8 | $34.6^{*}$ | $41.7^{*}$ | 32.2 | 30.4 | 33.9 |
| | 5-cm | 29.8 | $34.0^{*}$ | $35.3^{*}$ | $30.9^{*}$ | $30.1^{*}$ | 32.0 |
| | 10-cm | 29.5 | $30.5^{*}$ | $34.1^{*}$ | $28.0^{*}$ | 35.4 | 31.5 |
| Grass mulch | Surface | $31.0^{ns}$ | $29.7^{*}$ | $29.4^{*}$ | $32.0^{ns}$ | $28.7^{ns}$ | 30.1 |
| | 5-cm | $30.3^{ns}$ | $25.3^{ns}$ | $26.0^{ns}$ | $26.2^{ns}$ | $28.0^{ns}$ | 27.1 |
| | 10-cm | $29.1^{ns}$ | $25.3^{*}$ | $24.5^{*}$ | $25.2^{*}$ | $26.6^{ns}$ | 26.2 |
| Black polythene mulch | Surface | $29.6^{ns}$ | $33.3^{ns}$ | $34.4^{*}$ | $30.9^{ns}$ | $29.9^{ns}$ | 31.6 |
| | 5-cm | $28.5^{ns}$ | $31.7^{*}$ | $30.5^{*}$ | $28.5^{ns}$ | $28.9^{ns}$ | 29.6 |
| | 10-cm | $27.3^{*}$ | $28.9^{*}$ | $29.1^{*}$ | $27.8^{ns}$ | $27.1^{ns}$ | 28.0 |
| Clear plastic mulch | Surface | $30.8^{ns}$ | $34.4^{ns}$ | $31.9^{*}$ | $29.7^{ns}$ | $28.4^{ns}$ | 31.0 |
| | 5-cm | $30.8^{ns}$ | $32.2^{*}$ | $29.2^{*}$ | $28.3^{*}$ | $27.6^{*}$ | 29.6 |
| | 10-cm | $30.9^{ns}$ | $30.5^{ns}$ | $28.5^{*}$ | $26.3^{ns}$ | $26.5^{ns}$ | 28.5 |
| Newspaper mulch | Surface | $29.8^{ns}$ | $31.5^{*}$ | $34.7^{*}$ | $32.1^{ns}$ | $29.8^{ns}$ | 31.6 |
| | 5-cm | $27.7^{ns}$ | $28.5^{*}$ | $28.9^{*}$ | $28.2^{*}$ | $28.7^{ns}$ | 28.4 |
| | 10-cm | $27.2^{*}$ | $27.8^{*}$ | $26.7^{*}$ | $26.2^{ns}$ | $27.0^{ns}$ | 30.0 |
| Mean | Surface | 30.3 | 31.8 | 33.7 | 30.2 | 29.3 | 32.4 |
| | 5-cm | 29.6 | 31.2 | 30.7 | 29.1 | 28.8 | 28.4 |
| | 10-cm | 28.8 | 28.6 | 28.6 | 26.7 | 28.5 | 30.1 |
| [1]$LSD_{(0.05)}$ | Surface | 1.56 | 2.91 | 3.34 | 5.25 | 2.11 | - |
| | 5-cm | 1.76 | 1.38 | 2.61 | 2.40 | 1.57 | - |
| | 10-cm | 1.52 | 1.44 | 3.23 | 2.06 | 10.53 | - |

[1]Least significant difference;

*Significant at $P<0.05$ according to least significant difference test;

ns, not significant at $P>0.05$

**Soil temperature:** As shown in Table 8, unmulched soil had the highest mean surface soil temperature (33.9°C). Next were black polythene mulch (31.6°C), newspaper mulch (31.6°C) and lastly, clear plastic mulch (31.0°C). At 4 WAP, surface soil temperatures were significantly ($P<0.05$) highest (34.6°C) in the control than temperatures of newspaper (31.5°C) and grass mulch (29.7°C). At 6 WAP unmulched soil had significantly ($P<0.05$) higher temperature (41.7°C) than newspaper mulch (34.7°C), black polythene mulch (34.4°C), clear plastic mulch (31.9°C) and grass mulch (29.4°C). Mulch did not increase soil temperatures at surface, 5-cm depth and 10-cm depth, in agreement with a previous investigation [3] where it was reported that mulch protected the soil from extreme heat,

Table 9: Effects of mulching on soil chemical properties of dry bean soils

| | | % | | | ppm | | | |
|---|---|---|---|---|---|---|---|---|
| Mulch type | pH | N | Organic matter | Carbon | P | K | Mg | Ca |
| No mulch | 5.29 | 0.22 | 1.42 | 0.83 | 25.6 | 98.95 | 185.5 | 457.78 |
| Grass mulch | 5.04 | 0.26 | 1.24 | 0.72 | 24.3 | 99.08 | 173.75 | 433.25 |
| Black polythene mulch | 5.49 | 0.21 | 1.44 | 0.84 | 19.43 | 82.68 | 187.75 | 412.25 |
| Clear plastic mulch | 5.23 | 0.26 | 1.52 | 0.89 | 19.23 | 87.68 | 186.75 | 417.75 |
| Newspaper mulch | 5.31 | 0.24 | 1.38 | 0.8 | 15.65 | 87.4 | 188.75 | 466.25 |
| Mean | 5.27 | 0.24 | 1.4 | 0.81 | 20.84 | 91.05 | 184.35 | 437.45 |
| 1LSD(0.05) | 0.36 | 0.07 | 0.19 | 0.11 | 14.2 | 29.78 | 37.16 | 61.15 |
| Significance at $P<0.05$ | * | Ns | * | * | Ns | Ns | Ns | Ns |

[1]Least significant difference;

*Significant at $P<0.05$;

Ns, not significant at $P>0.05$

Table 10: Correlations between some soil parameters and grain yield in dry bean

| | Soil chemical properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | pH | N | Organic matter | Carbon | P | K | Mg | Ca |
| Correlation coefficient, r | 0.444 | -0.407 | 0.224 | 0.224 | 0.226 | 0.188 | 0.196 | 0.186 |
| Coefficient of determination, $R^2$ | 19.71 | 16.56 | 5.01 | 5.01 | 5.12 | 3.53 | 3.84 | 3.46 |
| Probability | 0.049 | 0.074 | 0.34 | 0.338 | 0.338 | 0.427 | 0.406 | 0.432 |
| Significance at $P<0.05$ | * | Ns | Ns | Ns | Ns | Ns | Ns | Ns |

*, Significant at $P<0.05$, according to least significant difference test.

Ns, not significant at $P>0.05$

as the unmulched soil did in this investigation. Our results agreed with previous reports [3, 15] that under mulch, temperatures were controlled more evenly and that temperature under mulch was more constant than without mulch. The results of this investigation were also in agreement with another report [23] that noted reduced soil temperatures under mulch.

**Soil chemical properties:** Table 9 shows the effects on mulch on soil chemical properties. Other than pH, organic matter and carbon, there were no significant differences among the mulches. However, grass mulch resulted in the lowest pH (5.04), whereas black polythene mulch raised the soil pH to 5.49. Thus, the mulches used did not lead to any acidification of soil, as some other mulch could do. The concentration of nitrogen in this investigation could imply that no mulch resulted in minimum N fixation, compared to higher concentration of N under the grass and clear plastic mulches. Table 10 shows correlations between some soil chemical properties and grain yield in dry bean.

Table 11: Influence of mulch on disease incidence from 2-10 WAP

| | Weeks after planting | | | | | | |
|---|---|---|---|---|---|---|---|
| Mulch type | 2 | 4 | 6 | 8 | 10 | Total | Means |
| No mulch | 1.2 | 2.4 | 1.2 | 1.0 | 1.0 | 6.8 | 1.4 |
| Grass mulch | 1.2 | 2.4 | 1.3 | 1.0 | 1.0 | 6.9 | 1.4 |
| Black polythene mulch | 1.2 | 2.2 | 1.2 | 1.0 | 1.0 | 6.6 | 13 |
| Clear plastic mulch | 1.2 | 1.7 | 1.4 | 1.0 | 1.0 | 6.3 | 1.3 |
| Newspaper mulch | 1.3 | 2.1 | 1.5 | 1.0 | 1.0 | 6.8 | 1.4 |
| Mean | 1.2 | 2.2 | 1.1 | 1.0 | 1.0 | 6.7 | 1.3 |
| [1]$LSD_{(0.05)}$ | 0.3 | 0.52 | 0.39 | 0.00 | 0.00 | N/A | N/A |
| Significance | NS | * | NS | NS | NS | N/A | N/A |

[1]Least significant difference;

*Significant at $P<0.05$; Ns, not significant at $P>0.05$

N/A, not applicable

**Disease incidence:** Table 11 shows the effects of mulch on disease incidence, at 2-10 WAP. Diseases were very few in this experiment. At 4 WAP, grass mulch and the unmulched plots had a significantly ($P<0.05$) higher disease incidence (disease score, 2.4 out of 6.0) than plots under clear plastic mulch (score, 1.7 out of 6.0). By 8 and 10 WAP, there were no diseases found in the experiment. Mean disease scores were the same (score, 1.4 out of 6.0) for the control, grass mulch and newspaper mulch. Black polythene mulch and clear plastic mulch had the lowest mean scores of 1.3 each, out of 6.0. Anthracnose (caused by *Colletotrichum lindemuthianum*) and damping off (incited by *Pythium debaryanum* and *Rhizoctonia solani*) were the diseases encountered. At harvest, there was a fungal disease (white mold, *Sclerotina sclerotiorum*) that was associated with heavy rains. Since the sun's rays could not reach the soil in mulched plots, this could have favored the incidence of white mold. The white mold infected some pods. Different types of mulching material had been reported [24] to contain germination and growth-inhibiting substances in them and this might account for decreased plant growth and decreased crop yields.

Grass mulch had the highest disease incidence probably because some disease-causing agents could be harbored in grass. Some pathogens use grass as either

Table 12: Influence of mulch on insect pests of dry beans at 2-10 weeks after planting

| | Weeks after planting | | | | | | |
|---|---|---|---|---|---|---|---|
| Mulch type | 2 | 4 | 6 | 8 | 10 | Total | Means |
| No mulch | 1.1 | 1.3 | 1.2 | 1.3 | 1.8 | 6.7 | 1.3 |
| Grass mulch | 1.1 | 1.4 | 1.5 | 1.3 | 2.4 | 7.6 | 1.5 |
| Black polythene mulch | 1.1 | 1.4 | 1.4 | 1.3 | 1.8 | 6.9 | 1.4 |
| Clear plastic mulch | 1.2 | 1.3 | 1.6 | 1.3 | 2.3 | 7.4 | 1.5 |
| Newspaper mulch | 1.1 | 1.3 | 1.4 | 1.3 | 1.8 | 6.8 | 1.4 |
| Grand mean | 1.1 | 1.3 | 1.4 | 1.3 | 2.0 | 7.1 | 1.4 |
| C.V. (%) | 9.0 | 8.3 | 9.8 | 15.7 | 14.7 | N/A | N/A |
| $LSD_{(0.05)}$ | 0.15 | 0.17 | 0.21 | 0.30 | 0.46 | N/A | N/A |
| Significance | N/A | NS | * | NS | * | N/A | N/A |

*Significant at P<0.05; NS, not significant; N/A, not applicable

their alternate or alternative host. Another reason could be that, as the grass was not sterilized, it could have introduced diseases that infected the beans. Mulch did not control the incidence of disease in this investigation. Previous reports showed that grass could be used to reduce rain splash and so reduce the incidence of black rot in cabbage [25]; transparent plastic was reported [26] to reduce aphid and whitefly infestation in cantaloupe (*Cucumis melo* L.).

**Insect pest infestation:** Grass mulch and clear plastic mulch showed the highest insect pest infestations (Table 12), with each having a mean score of 1.5 out of 5.0. Black polythene mulch and newspaper mulch followed, with a mean score of 1.4 each out of 5.0. The unmulched plots resulted in the lowest insect pest infestation (score, 1.3 out of 5.0). Insect pest scores showed significant differences (P<0.05) at 6 and 10 WAP. There were no significant differences at 2, 4 and 8 WAP. At 6 WAP, clear plastic and grass mulch showed significantly (P<0.05) higher insect pest scores (scores, 1.6 and 1.5 out of 5.0, respectively) than the control (score, 1.2). At 10 WAP, grass mulch and clear plastic mulch had significantly (P<0.05) higher insect pest scores (scores, 2.4 and 2.3 out of 5, respectively) than the control, newspaper mulch and black polythene mulch (each with a score of 1.8 out of 5.0).

That grass mulch had the highest number of insect pests could be because grass was a good camouflage for some pests, especially the spiny brown bugs and some grasshoppers. Increased yield losses due to insect pests could have resulted from increasing pest populations with advancing cropping season [27-29]. It was noted [28] that as crop yields rise, much research is needed to maintain past yields while insect pests, diseases and weeds find new niches or vary in the struggle to preserve old niches. Mulches were reported [30] to cause no reduction in levels of pest infestation, but could enhance plant tolerance to the pest and also reduce subsequent plant mortality compared to control plants.

## CONCLUSION AND RECOMMENDATIONS

This investigation showed that mulching had advantages such as increasing the number of leaves and length of pods per plant, as well as conserving soil moisture. However, mulching did not significantly increase grain yields. Since the procurement and application of mulch could imply additional labor inputs, it is recommended that dry beans be not mulched, but timely weeding should be carried out.

## REFERENCES


1. Luellen, W.R., N.H. Rhodehamel, B. Seybold and G. Korts, 1994. Photosynthetic nitrogen use-efficiency in relation to leaf longevity in Common Bean Crop. Crop Sci. J., 34: 1284-1290.
2. Kamara, C.S., 1980. The effects of planting dates and mulching on cow peas. Exper. Agric., 17: 25.
3. Mtshali, T.X.F., 1984. The measurement of available water in the soil under different tillage regimes with emphasis on mulching. Unpublished B.Sc. Dissertation, University of Swaziland, Luyengo.
4. Ministry of Agriculture and Cooperatives, 2007. Grain Legumes Research. Swaziland Government. http://www.gov.sz/home.asp?pid=1875. 06/29/07.
5. Newstarget, 2005. Diseases caused by meat. http://wwwnewstarget.com/007237-02.html. 09/14/2005.
6. Montshiwa, P., 1981. Effect of weeding frequency on growth and yield of cowpeas (*Vigna unguiculata* L.) Walp. Unpublished B.Sc. Dissertation, University of Swaziland, Luyengo.
7. Cubero, J.I., 1994. Traditional varieties of grain legumes for human consumption. In: Neglected Crops: 1492 from a different perspective. Hernándo, J.E. Bermejo and J. León (Eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. pp: 289-301.
8. Anonymous, 1999. Field crops production. In: Pitts, C.W. (Ed.). Farmer's handbook. Ministry of Agriculture and Co-operatives, Mbabane, Swaziland, pp: 12-14.

9. Yang, H. and M. Yen, 1996. A computation method to estimate moisture content by product weight. California Agricultural Technology Institute-CATI, College of Agricultural Sciences and Technology, California State University, Fresno, USA.
10. Ossom, E.M., P.F. Pace, R.L. Rhykerd and C.L. Rhykerd, 2001. Effect of mulch on weed infestation, soil temperature, nutrient concentration and tuber yield in *Ipomoea batatas* (L). Lam. in Papua New Guinea. Trop. Agri. (Trinidad), 78: 144-151.
11. Augustin, S., S. Guichard, A. Svatoš and M. Gilbert, 2004. Monitoring the Regional Spread of the Invasive Leafminer Cameraria ohridella (Lepidoptera: Gracillariidae) by Damage Assessment and Pheromone Trapping. Environ. Ent., 33: 1584-1592.
12. Mkhatshwa, A.B., 2002. Effect of planting dates and cultivars on the incidence and damage of beans (*Phaseolus vulgaris* L.) by field pests at Luyengo. Unpublished B.Sc. Thesis, University of Swaziland, Luyengo campus, Swaziland.
13. Smithers, C., 1981. Handbook of insect collecting. Delta Books, Johannesburg, South Africa.
14. Steel, R.G.D., J.H. Torrie and D.A. Dickey, 1997. Principles and procedures of statistics: A biometrical approach, 3rd Edn. McGraw-Hill, New York, USA.
15. Bell, G.D.H., R.E. Evans, J. Hamond, B. Keen, J.E. Russell, R.K. Schofield and F. Yates, (Eds.), 1960. Effect of black polythene mulch on soil microclimate and temperature and nitrate level. Agron. J., 52: 307-309.
16. Gent, M.P.N. and R.K. Kiyimoto, 1998. In: Optimization of vertical distribution of canopy nitrogen: An alternative trait to increase yield potential in winter cereals. Basra, A. S. (eds.). Crop Sciences: Recent advances. The Food Products Press, Binghamton, New York, USA, pp: 27-46.
17. Nunez Barrios, A., G. Hoogenboom and D.S. Nesmith, 2005. Drought stress and the distribution of vegetative and reproductive traits of a bean cultivar. Sci. agric. (Piracicaba, Braz.), Piracicaba, 62: 18-22.
18. Quattar, S., R.J. Jones and R.K. Crookston, 1987. Effect of water deficit during grain-filling on the pattern of maize kernel growth and development. Crop Sci. J., 27: 697-703.
19. Staples, R.C. and R.J. Kuhn, 1980. Linking research to crop production. Plenman Press, New York, USA.
20. Gunasekera, C.P., L.D. Martin, G.H. Walton and K.H.M. Siddique, 2003. Growth, dry matter production and seed yield of Indian mustard (*Brassica juncea* L.) in the Mediterranean environment of South Western Australia. Muresk Institute of Agriculture, Curtin University of Technology, Northam., Australia.
21. Hummell, C. and E. McKay, 2006. Maximizing soil moisture through mulch and slash applications. Oregon State University, Oregon, USA.
22. Walker, R.F. and S.B. Mclaughlin, 1989. Black polyethylene mulch improves growth of plantation-grown loblolly pine and yellow-poplar. New Forests, 3: 265-274.
23. Buerkert, A., A. Bationo and K. Dossa, 2000. Mechanisms of residue mulch-induced cereal growth increases in West Africa. Soil Sci. Soc. Am. J., 64: 346-358.
24. Maiti, R.K., 1997. Bean Science. Science Publishers, Inc., Enfield.
25. Onsando, J.M., 1987. Management of black rot of cabbage (*Xanthomonas campestris pv. campestris*) in Kenya. Tropical Pest Management, 33: 5-6.
26. Orozco-Santos, M., O. Perez-Zamora and O. Lopez-Arriaga, 1995. Floating row cover and transparent mulch to reduce insect populations, virus diseases and increase yield in cantaloupe. Florida Ent., 78: 493-501.
27. Cardwell, K.F., F. Schulthess, R. Ndemah and Z. Ngoko, 1997. A systems approach to assess crop health and maize yield losses due to pests and diseases in Cameroon. Agriculture, Ecosystems and Environment, 65: 33-47.
28. Evans, L.T., 1996. Crop evolution, adaptation and yield. Cambridge University Press, Cambridge.
29. Chrispeels, M.J., D.E. Sadava and M. Martinj, 2002. Plants, genes and crop biotechnology. Jones and Bartlett Publishers, Sudbury, MA 01776.
30. Madhiyazhagan, R., 2005. Global theme on agroecosystems.www.gt.agroecosystems.html. 06/02/2006.