American Journal of Plant Sciences, 2016, 7, 1040-1045
Published Online May 2016 in SciRes. http://www.scirp.org/journal/ajps
http://dx.doi.org/10.4236/ajps.2016.77099

Scientific Research Publishing

Quantitative Behaviour of Guar (*Cymopsis tetragnolobus* L.) to Various Tillage Systems and Mulches and Soil Physical Properties

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Received 6 February 2016; accepted 9 May 2016; published 12 May 2016

Abstract

A field study was conducted to evaluate the effect of organic mulches and tillage practices on growth, yield of cluster bean and soil physical properties. Experiment was comprised of two factors: A (Tillage), B (Mulches). Factor A was assigned to main plot and consisted of two treatments (Minimum tillage and Conventional tillage). Factor B was assigned to sub plot and consisted of four treatments (no mulch, wheat straw mulch, grass clipping mulch and saw dust mulch). The mulching materials were partially incorporated in the field after germination of crop. The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement having three replications. Control treatment was kept for comparison. All other agronomic practices were kept standardized and consistent for all the treatments. Data regarding growth and yield components were collected and analyzed statistically by fisher analysis of variance and treatment significance was measured by significant difference test at 5% probability level. The factors, tillage and mulches significantly affected growth, yield, yield parameters and soil physical properties. Maximum plant population (31.7 m^2), plant height (159 cm), branches per plant (18.9), cluster per plant (15.88), grains per pod (7.3), 1000-grain weight (34.6 g), grain yield (1.9 $t \cdot ha^{-1}$), biological yield (9.91 $t \cdot ha^{-1}$) and harvest index (19.15) was recorded in conventional tillage comparative to minimum tillage. Mulches also affected grain yield, and maximum grain yield was recorded in wheat straw mulch (1.88 $t \cdot ha^{-1}$) followed by grass clipping mulch (1.81 $t \cdot ha^{-1}$) and saw dust mulch (1.76 $t \cdot ha^{-1}$) while minimum grain yield was recorded in control without mulch application (1.67 $t \cdot ha^{-1}$). Tillage and mulches interactively affect pH, soil organic matter contents,

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How to cite this paper: Zamir, M.S., Khan, M.A., Hussain, M., Haq, I., Khan, M.K., Zaman, Q., Afzal, U., Islam, N., Asim, M., Ali, I., Khan, H. and Iqbal, K. (2016) Quantitative Behaviour of Guar (*Cymopsis tetragnolobus* L.) to Various Tillage Systems and Mulches and Soil Physical Properties. *American Journal of Plant Sciences*, **7**, 1040-1045.
http://dx.doi.org/10.4236/ajps.2016.77099

electrical conductivity and soil bulk density. Mulches and minimum tillage improved soil physical properties. Highest BCR was obtained from conventional tillage without mulch and lowest calculated from minimum tillage with saw dust application. The conclusion is that the mulching and conventional tillage improves cluster bean yield about 1%.

Keywords

Guar, Mulch, Tillage, Soil Properties

1. Introduction

Guar (*Cymopsis tetragnolobus* L.) is an important drought and high temperature tolerant export crop of Pakistan. It is leguminous crop of high socio-economic significance and mainly cultivated in Kharif season. In Pakistan, it was cultivated on an area of 0.24 million hectare with annual production 0.146 million ton and average yield 630 kg/ha that is far less than India and other countries. Pakistan is major exporter of guar gum that fully fills 10% - 15% of world demand. In Pakistan, guar is mostly grown on marginal lands in Thar, Kohistan, Nara valley, Thal, Cholistan and Las Bella Hills. In vegetative form, it is mostly used for forage and green manuring but its commercial product is guar gum that is mostly used in medicine, food, beverages, petroleum and for different industrial purpose as viscosifying, stiffener, stabilizer and gelling agent [1]. As a leguminous crop, guar roots bear nodules where nitrogen fixing bacteria inhabit and involve in biological nitrogen fixation, so guar crop is intercropped or cultivated in rotation for making soil fertile.

Guar crop is mainly cultivated on marginal lands in rain fed conditions and thus influenced to much extent by the monsoon received in the Guar growing areas during sowing time. Its yield and acreage are highly dependent on rainfall. Among crop production factors, tillage plays a pivotal role. Soil tillage is the establishment of any crop fabrication system and is the biggest factor in Guar production. It maintains the accessible structure or improves the poorly structured soils. With the development of high yielding cultivars, nutrient and moisture requirement has been increasing. To fulfill these requirements, role of tillage and soil organic matter can't be over looked particularly in arid conditions. Tillage is the most important factor in reducing soil erosion. Mulching is a practice in which we leave or spread plant residues and other inorganic materials on the soil surface for moisture and soil conservation. Mulches protect soil from drying and baking effect that leads to less evaporation and optimum soil temperature. [2] reported that mulches increase soil fertility and microbial activity of the soil by adding valuable amount of organic carbon. In addition, mulches also decrease the fluctuations of temperature soil by providing coverage to the soil that helps to reduce evaporation from soil surface. Organic mulches improve soil, pleasant soil temperature, hinder weed growth, lesson soil moisture evaporation and improve the visual qualities of landscape. A good layer of mulch will help to suppress weeds and thus decrease weed-crop competition that is helpful in moisture conservation. Straw mulch is practiced successfully in many advanced countries like America and Australia where it improved many soil aspects as support soil moisture improvement. Keeping in view, the present trial was carried out to assess the influence of tillage systems and organic mulches on guar yield and soil physical properties.

2. Materials and Methods

A field study was conducted to evaluate the most suitable organic mulch under conventional and minimum tillage at Agronomic Research Area, University of Agriculture, Faisalabad, during summer 2014. Experiment was comprised of two factors A (Tillage), B (Mulches). Factor A was assigned to main plot and consist of two treatments (Minimum tillage and Conventional tillage). Factor B was assigned to sub plot and consisted of four treatments (no mulch, wheat straw mulch, grass clipping mulch and saw dust mulch). The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement having three replications with net plot size 3 m × 7 m. The crop was sown in 30 cm spaced rows with hand drill during the 1st week of June, 2014. All other agronomic practices were kept standardized and consistent for all the treatments. During the whole crop season observations was recorded on growth, agronomic and yield related traits by following standard procedure. Soil physicochemical analysis was done prior to planting and after harvesting of crop by fol-

lowing standard procedure. The collected data was analyzed statistically using Fisher's analysis of variance technique and treatments' means was compared by employing least significant difference (LSD) test at 5% probability level.

3. Results

Treatment means revealed that tillage systems and mulch practices considerably enhanced the yield and yield related parameters. Conventional tillage proved to be better as compared a minimum tillage. Conventional tillage substantially increased the plant height, number of branches, clusters, and number of grains per plant, 1000 grain weight, biological yield, and grain yield and harvest index as compared to minimum tillage. A minimum value of all these recorded parameters was obtained in minimum tillage (**Table 1**). Application of mulches also improved the yield and yield related the parameters. For mulch practices wheat straw mulches proved to be better as compared to other mulch materials. For mulch practices a maximum value of plant height, number of branches, clusters, pods and number of grains per plant, 1000 grain weight, biological yield, grain yield and harvest index was obtained maximum in wheat straw mulch that was statistically at par with grass clipping mulch, application of saw dust mulch increased all these recorded parameters but lower than as compared to wheat straw mulch and grass clipping mulch. The minimum value of these recorded parameters was found in control without mulch application. The interaction between tillage and mulches was found non-significant for growth and yield parameters.

Tillage systems and mulch practices also markedly improved the soil properties. Minimum proved better in improving the soil properties as compared to conventional tillage. A maximum value of soil pH, and soil bulk density was observed in conventional tillage as compared to minimum tillage. The minimum value of soil pH the increase nutrient availability to plants and minimum value of soil bulk density improved soil physical condition which facilitates root proliferation. The maximum value of soil organic matter was observed in minimum tillage in comparison to conventional tillage. Minimum tillage proved to be better in increasing the soil organic matter contents as compared to conventional tillage. For mulch applications wheat straw mulch proved better as compare to other mulch practices. The minimum value of soil pH and soil bulk density was observed in wheat straw while maximum value of soil pH and soil bulk density was obtained in control without mulch application. Wheat straw mulch also markedly increased the soil organic matter percentage as compared to other mulch practices. The interaction between tillage and mulches was found significant for soil physical properties. In interaction effect the maximum value of soil pH and soil bulk density was recorded in conventional tillage with no mulch application however minimum value of soil pH and soil bulk density was found in minimum tillage with wheat straw mulch application. In interaction effect maximum value of soil organic matter percentage was obtained in minimum tillage with wheat straw mulch application, however minimum value of soil organic matter

Table 1. Growth and yield parameters as influenced by tillage systems and mulches.

Tillage	Plant population (m^2)	Plant height (cm)	No. of Branches $Plant^{-1}$	No. of cluster $Plant^{-1}$	Number of pods/plant	Number of grains/ pod	1000-grain weight (g)	Grain yield ($t \cdot ha^{-1}$)	Biological yield ($t \cdot ha^{-1}$)	Harvest index (%)
Conventional tillage	31.7a	159a	18.9a	15.88a	27.69b	7.3a	34.6a	1.90a	9.91a	19.15a
Minimum tillage	24.8b	132b	11.6b	9.64b	35.39a	5.9b	31.95a	1.67b	9.37b	17.79b
LSD ($P \leq 0.05$)	4.4108	14.837	2.55.5	0.3837	2.72	0.7452	2.0126	0.0952	0.1891	1.2459
Mulches										
No mulch	28.8a	127d	12.8c	9.82b	29.78c	6.0b	31.95b	1.67c	9.33c	17.90b
Wheat straw mulch	27.8a	158a	16.7a	14.75a	33.38a	6.9a	33.53a	1.88a	9.94a	18.92a
Grass clipping mulch	28.6a	152b	16.2ab	13.27a	32.34b	6.7a	33.42a	1.81b	9.69b	18.70a
Saw dust mulch	27.1a	145c	15.3b	13.21a	31.55bc	6.7a	33.27ab	1.76b	9.59b	18.37ab
LSD ($P \leq 0.05$)	2.2308	4.4354	1.6506	1.9464	3.80	0.5719	1.3780	0.0550	0.1920	0.5912

percentage was obtained in conventional tillage without mulch application.

4. Discussion

Conventional tillage increased plant population due to conservation of more soil moisture and increased availability of moisture for better seed germination. These results are in line with previous conclusions of [3] they recorded higher number of plants in conventional tillage as compared to minimum tillage system. Number of plants per square meter was not affected by mulch practices because mulches were partially incorporated after seedling emergence. Taller plants in the conventional tillage and wheat straw mulch might be due to good soil physical conditions and more water conservation under wheat straw mulch. Such results were also observed by those of [4] and [5] who reported that greater plant height, grain yield and biological yield were also seen in case of mulching with tillage. Conventional tillage with mulch application increased the number of branches per plant due to positive effect of tillage in lowering the soil temperature and in preserving the soil moisture results in more availability of nutrients from source to sink. These outcomes are in line with previous results of [6] which have stated that conventional tillage with mulch practices is the best way to increase the yield and yield components.

The number of cluster is important yield contributing parameter improved by tillage systems and mulches might be due to improvement in soil aeration results in better availability of moisture and nutrients. Similar results were also reported by [7] they found improvement in yield components in conventional tillage as compared to minimum tillage and [8] and [9] reported positive effects of mulches on yield components. Among major yield boosting components of plant, number of pods per plant is one of them which can multiply or divide the grain yield. The higher number of grains per pod in the wheat straw mulch treatments might be due to changes in soil physical, chemical and biological characteristics [10].

All the tillage practices and mulch treatments significantly affected 1000 grain weight of a crop that has a vital role in the final grain yield. Higher thousand grain weight in conventional tillage + wheat straw might be due to proper moisture availability and frequent availability of nutrients. Furthermore, soil covering by mulch throughout the cropping seasons improves soil physical properties. These findings were supported by [11] who reported that height of plant, number of green leaves, number of grains per ear and grain weight were higher in conventional tillage and mulch application.

The higher grain yield in the conventional tillage and the wheat straw mulch may be due to better utilization of water and nutrients in the field conditions by the cluster bean plot roots. Moreover, the better contributions of yield building factors *i.e.* number of grains per pod and 1000 grain weight among the all other tillage and mulch treatments may resulted in good final grain yield. These results were supported by [12] who reported that more grain yield was in conventional tillage crop comparative to conservation tillage. Similarly observed that, mulches applied on soil increased grain yield significantly as compared with bare soil. More plant biomass in conventional tillage treatment may be attributed to the more plant height and more number of leaves per plant and more crop growth rate. These results are supported by those of [13] and [14]. They reported that the conventional tillage improved the root length and water availability as the root was gone for the extraction of storage of water in the deeper profiles of soil.

Data presented in **Table 2** showed that tillage and mulch treatments significantly affected the soil organic matter contents. It was observed that wheat straw mulch showed better results in combination with tillage than saw dust mulch. These conclusions are compatible to those of [15] who reported that the effect of straw mulch on soil mineral nitrogen and organic matter content were smaller and conflicting. The data regarding soil pH showed that all the treatments were statistically equal and had same effects on soil pH. Greater increase in soil pH was observed where mulch was applied with tillage than controlled treatments. These results are in line with those of [16]. Data presented in **Table 2** indicated that tillage practices and mulches have significant effect on soil bulk density. These findings are also in compliance with [17] who concluded that the incorporation of crop residues like wheat straw combined with fertilizer and tillage practices improved soil physical characteristics (infiltration rate, bulk density and hydraulic conductivity). Bulk density is significantly decreased by enhancing tillage practices [18]. The soil having 3 - 20 cm layer significantly increased the bulk density. The deep tillage treatments decreased bulk density significantly than in no tilled soils because of increasing pore size distribution and hard layer breakage [19].

Soil electrical conductivity is measure of presence of soluble salts; moisture and nutrient contents in soil. Both

Table 2. Soil parameters as influenced by tillage systems and mulches.

Tillage	Soil pH	Soil organic matter	EC	Soil bulk density
Conventional tillage	7.55a	0.80a	1.67a	1.48a
Minimum tillage	7.50b	0.83b	1.35b	1.40b
LSD ($P \leq 0.05$)	0.0200	0.0251	0.0313	0.0436
Mulches				
No mulch	7.58a	0.75c	1.2c	1.51a
Wheat straw mulch	7.55b	0.86a	1.66a	1.40c
Grass clipping mulch	7.50c	0.85a	1.65a	1.39c
Saw dust mulch	7.48c	0.80b	1.53b	1.47b
LSD ($P \leq 0.05$)	0.0320	0.0188	0.0310	0.0178
Interaction				
$T_1 \times M_1$	7.59a	0.75d	1.15f	1.54a
$T_1 \times M_2$	7.58ab	0.84b	1.89a	1.45cd
$T_1 \times M_3$	7.54bc	0.84b	1.88a	1.43d
$T_1 \times M_4$	7.47e	0.79c	1.76b	1.51b
$T_2 \times M_1$	7.57ab	0.75d	1.25e	1.48bc
$T_2 \times M_2$	7.51cd	0.89a	1.43c	1.34e
$T_2 \times M_3$	7.45e	0.87a	1.41c	1.34e
$T_2 \times M_4$	7.48de	0.81bc	1.30d	1.43d
LSD ($P \leq 0.05$)	**0.045**	**0.0266**	**0.0438**	**0.0252**

tillage practices and organic mulch have significant effect on electrical conductivity (Ec) of soil. Wheat straw mulch in combination with tillage gave higher electrical conductivity of the soil than saw dust mulch and controlled treatments. It was observed that soil physical properties that are influenced by conservation tillage and mulching include bulk density, infiltration and water retention, Ec, soil compaction [20]. Soil suitability is necessary for sustaining plant growth. The biological activity and soil suitability is function of soil physical and chemical properties (Ec, hydraulic conductivity) which depends on the quality and quantity of soil organic matter [21]. [22] reported that by using mulch the electrical conductivity of soil decreases 53% as compare to unmulched treatments.

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