ISSN: 0067-2904
GIF: 0.851

# Combining Effect of Different Rates of *Sorghum bicolor* (L.) Moench Residues and Reduced Rates of Trifluralin on Weeds in Mung Bean Field

**Laith Z. Al-Obaidi , Ibrahim S. Alsaadawi***
Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq.

**Abstract**

Field and laboratory experiments were performed to evaluate the allelopathic potential of sorghum residues alone or in combination with reduced rate of trifluralin herbicide on weeds in mung bean field. The field experiment was conducted during 2014 season at the Research Farm of Biology Department, College of Science, Baghdad University by using randomized complete Block design (RCBD) to test the effect of sorghum residues at rates of 5 and 10 t $ha^{-1}$ alone or in combination with reduced doses of trifluralin (30 and 60% of recommended dose) on weeds and mung bean crop. Weedy check and label rate of trifluralin (2.4 $Lha^{-1}$) were also included for comparison. Each treatment was replicated four times. Total phenolics in field soil amended with sorghum residues at 10 t $ha^{-1}$ was determined in at 0, 14, 28 and 42 days of sorghum residues decomposition. Also bioassay experiment was conducted to test the allelopathic effect of sorghum residues at 10 t $ha^{-1}$ incorporated into the field soil on seedling emergence and growth of *Portulaca oleracea* weed during the above mentioned decomposition periods. Results showed that incorporation of sorghum residues at 5 t $ha^{-1}$ reduced weed density by16.9 and 18.8% of control after 30 and 60 days from sowing, respectively. The reduction was increased when sorghum residues were incorporated at 10 t $ha^{-1}$ and reached to 30 and 30.5% of the control after 30and 60 days from sowing, respectively. However, the suppression of weed population and dry weight biomass was further improved when the plots were treated with 30 and 60% of label rate of trifluralin and sorghum residues at 5and 10 t $ha^{-1}$. The highest suppression of weed population and dry biomass was achieved by application of reduced rate of trifluralin (60%) to plots amended with sorghums residues at 10 t $ha^{-1}$. Integration of reduced herbicide and sorghum residues at 5and 10 t $ha^{-1}$ resulted in more weed suppression than sole application of the respected sorghum residues. The results also revealed that weed suppression was directly translated into yield of mung bean. Application of trifluralin herbicide at 60% of label rate in plots amended with sorghum residues at 10 t $ha^{-1}$ recorded the highest biological and grain yield, number of pods per plants and weight of 100 seeds. Chemical analysis indicated that total phenolics started to increase at14 and 28 days of decomposition and decline thereafter until vanished 6 weeks of decomposition. Biological activity test of field soil revealed that suppression of *Portulaca oleracea* weed was highly correlated with total phenolics ($R^2$ = 0.95for seedling emergence and 0.87 for dry biomass) of soil suggesting that high weed suppression was mainly due to high activity of phenolics.

**Keywords**: Allelopathy, sorghum residues, reduced herbicide, mung bean

*Email:Ibrahim_alsadawi@yahoo.com

# تأثير التداخل بين معدلات مختلفة من مخلفات الذرة البيضاء مع جرع منخفضة من مبيد الترفلان في ألأدغال النامية في حقل محصول الماش

**ليث زهير العبيدي ، أبراهيم شعبان السعداوي***

قسم علوم الحياة ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

**خلاصة**

نفذت تجربة حقلية وتجارب مختبرية لاختبار الجهد الاليلوباثي مخلفات الذرة البيضاء صنف أنقاذ بمفردها اومع جرع منخفضة من مبيد الترفلان في مكافحة الادغال النامية في حقل محصول الماش. نفذت التجربة الحقلية في الموسم 2014 في حقل تجارب قسم علوم الحياة، كلية العلوم، جامعة بغداد، اذ أستعملت مخلفات الذرة البيضاء صنف أنقاذ المضاف بمعدل 5 و 10 طن هـ$^{-1}$ بصورة منفردة أو مع جرع منخفضة من مبيد الترفلان (30 و60 %) من الجرعة الموصى بها لدراسة تاثيرها في مكافحة الادغال في حقل الماش ومحصوله. كما تضمنت الدراسة معاملة بدون مكافحة (مدغلة) ومعاملة مبيد بالجرعة الموصى بها للمقارنة. أستعمل تصميم القطاعات العشوائية الكاملة RCBD وبأربعة مكررات. كما تم تحديد المحتوى الكلي للفينولات لتربة الحقل المخلوطة بها مخلفات الذرة البيضاء بمعدل 10 طن هـ$^{-1}$ بعد 1 و 14 و 28 و 42 يوما من اضافة المخلفات. نفذت تجربة في اصص لتقدير النشاط الحيوي للتربة المخلوطة بالمخلفات على بزوغ ونمو نبات البربين خلال المدد الزمنية آنفة الذكر .أظهرت النتائج أن مخلفات الذرة البيضاء المضافة الى تربة الحقل بمعدل 5 طن هـ$^{-1}$ أختزلت كثافة الادغال بنسبة 16.9 و18.8% عن المقارنة بعد 30 و60 يوما من الزراعة على التتابع، وأزداد هذا الاختزال عند زيادة المخلفات المخلوطة الى 10 طن هـ$^{-1}$ ليصل الى 30 و 30.5% عن المقارنة بعد 30 و60 يوما من الزراعة على التتابع. ألا أن الاختزال ازداد بشكل كبير عندما استعملت تراكيز من مبيد الترفلان (30 و60%) مع مخلفات الذرة البيضاء بتركيز 5 و10 طن هـ$^{-1}$ .وسجل أعلى أختزال لاعداد الادغال وأوزانهاالجافة في معاملة المخلفات بتركيز 10 طن هـ $^{-1}$ مع أضافة 60 % من الجرعة الموصى بها من مبيد الترفلان، كما أظهرت التجربة أن أختزال الادغال وأوزانها الجافة ازداد في المعاملات الحاوية على المبيد مع المخلفات أكثر من تلك الحاوية على المخلفات فقط.لقد أظهرت النتائج ان الانخفاض في كثافة الادغال قدانعكس تاثيره ايجابيا في الحاصل. فقد بينت النتائج ان معاملة مخلفات الذرة البيضاء بتركيز 10 طن هـ$^{-1}$ مع 60% من المبيد أعطت حاصلا بايولوجيا وحاصلا للبذوروعدد قرانات بالنبات الواحد ووزن 100 بذرة ودليل حصاد أعلى من المعاملات الاخرى.وأظهرت نتائج التحليل الكيميائي ان المحتوى الكلي للفينولات قد أزداد بعد 14 يوما ووصل الى اعلى مستوى له بعد 28 يوما من التحلل بعدها هبط الى ان تلاشى بعد 6 أسابيع من التحلل. وقد أرتبط تثبيط دغل البربين البري بصورة معنوية عالية مع المحتوى الكلي للفينولات في التربة وهذا ،يشير الى ان التثبيط العالي لدغل البربين كان نتيجة التراكيز العالية للفينولات.

## Introduction

Allelopathy is the direct influence of chemicals released from one plant on the growth and development of another plant [1]. Multiple physiological effects have commonly been observed from many allelochemicals released from allelopathic plants. Allelopathy plays a major role in natural ecosystems by determining vegetational patterning, plant dominance, plant succession, plant biodiversity, preventing seed decay and causing seed dormancy [2]. Also, allelopathy has a significant role in agricultural ecosystems such as weed-crop, crop-weed, crop-crop, forestry and nutrient cycling [3].

During the last four decades, the results of allelopathic effects of crops on weeds revolutionized the scientists to put much effort on this aspect with the aims of using this phenomenon to reduce the dependence on chemical herbicides for weed control [4,5]. Different strategies in which allelopathy is involved have been suggested such as using allelopathy in crop rotations, cover crops and mulches, smother crop, crop mixtures and intercropping and use of allelopathic crop residues or extracts [6].

Allelopathic crop residues as mulch or incorporated into field soil have been found to be the most successful strategy in weed suppression. However, in most cases, the efficacy of allelopathic residues was generally below that of herbicides. Therefore, many researchers have discussed the possibility of integrating allelopathic residues with other managing options for weed control. [7] suggested that a herbicide applied in combination with allelopathic conditions could enjoy a complementary interaction, and may help to minimize herbicide usage for weed management in field crops.

The combination of allelopathic crop extract with lower rate of herbicide was first explored by Cheema group in Pakistan during the last decade. These scientists postulated that herbicide use can be reduced by 50 – 70 % when herbicides are used in combination with aqueous sorghum extracts for weed control in field crops such as wheat, cotton, mung bean and maize (8-11). Although successful results have been obtained from allelopathic plants extract applied with low herbicide rates, additional work in other soil types and to employ this technology, large volumes of sprays are required for field application, and therefore appropriate concentrations for each crop should be determined for large scale field operations [6]. Due to these limitations, an alternative practical and feasible approach has been developed by Alsaadawi group where the residues of allelopathic crops including sorghum have been left to dry under field conditions and then promptly incorporated into production sites for weed management [12-14]. Low herbicide doses were applied along with residue incorporation. By using this approach with faba bean, wheat, barley, cowpea and mung bean, it was found that application of half the labeled rates of the test herbicide in field soil amended with sorghum or sunflower residues suppress weeds and generated crop yield similar to that of the label (full) rate of herbicide. Although information regarding the integration effect of allelopathic potential of sorghum residues with lower rate of herbicide on weeds of various crops is available. Nonetheless, combined allelopathic potential of sorghum residues with reduced rate of herbicide against weeds in mung bean had never been reported. Therefore, the present study was conducted to assess the combined effect of allelopathic potential of sorghum residues with reduced doses of trifluralin on weeds and mung bean yield.

## Materials and methods

### Site description

The proposed study was conducted at Research field of Biology Department, College of Science, Baghdad University, Baghdad, Iraq. During the spring season of August 2014 where the previous field history showed heavy weed infestation. The soil of experimental site was calcareous clay loam. Organic carbon, pH and EC were 0.92%, 7.2 and 1.9 dS $m^{-1}$, respectively. Average annual rainfall is less than 50 mm and day/night temperatures during the growing season were 30-45 $^{\circ}$C.

### Seeds and herbicide sources

Seeds of sorghum cv. Enkath As grow and grain of mung bean cv. Abu Ghraib were obtained from Department of Crop Sciences, College of Agriculture, Department of crops, Baghdad University. Treflan (trifluralin) herbicide was purchased from local market. The herbicide is a product of Arabic company for herbicides and tertiary medicines industry.

### Preparation of sorghum residues

To prepare sorghum residues, field plot (8 x 10m) were tilled twice at the beginning of May, 2014. Seeds of sorghum cultivar cv. Enkath were sown in 75 cm apart rows with a distance of 20 cm between seeds in order to achieve target density of 6.6 plants per $m^2$ [15]. Fertilizers (nitrogen as urea (46% N) at 240 kg $ha^{-1}$ and phosphorus as triple super phosphate (46 % $P_2O_5$ ) at 160 kg $ha^{-1}$ which were applied as recommended for this crop, all phosphorous and half of the nitrogen were applied at planting while the remaining half of the nitrogen (120 kg $ha^{-1}$) was applied at flowering stage [16]. Irrigation was applied as recommended for this crop. At physiological maturity, the heads were removed, mature sorghum plants were harvested in July 25, 2014, air dried for several days under plastic shed during summer and chopped into pieces of about 2-3cm pieces using electrical grinder and kept until use. Based on previous results by [17] , it was found that 6.6 mature plants of sorghum that occupied 1 $m^2$ area added about 10 ton (t) of air - dried tops per hectare ( ha ) of soil to a depth of 30 cm, therefore , residue rates at 5 t $ha^{-1}$ and 10 t $ha^{-1}$ were used in this experiment to test their effects on weeds and mung bean crop.

### Implementation of experiment

The field was tilled twice and divided into plots measuring 1 × 1.5 m on first of August 2014. Nitrogen as urea (46% N) at 20 kg $ha^{-1}$ and phosphorus as triple super phosphate (46% $P_2O_5$) at 60 kg $ha^{-1}$ were applied to these plots as recommended for mung bean crop. All phosphorus and half of the nitrogen were applied at planting during seed bed preparation, while remaining nitrogen was applied after one month of sowing. Uniform seeds of mung bean *Vigna radiate* (L.) Wilczek were manually sown in August 7, 2014 in all plots in 30cm spaced crop rows keeping plant to plant distance of 15cm. All plots received recommended irrigation water during the entire course of study. Residues of sorghum cultivar were incorporated into the soil of field plots at rates of 5 and 10 t $ha^{-1}$. A weedy check without sorghum residues, weedy free and label rate of trifluralin herbicide (2.4 L $ha^{-1}$) were included in the experiment for comparison. Weeds from weedy free plots were removed every week by hand pulling throughout the crop's life span. Trifluralin herbicide was sprayed on plots on planting day of mung bean, Trifluralin herbicide was sprayed on plots on planting day of mung bean, using hand sprayer fitted with T- Jet nozzle at a pressure of 270 k Pa. The experiment was laid out in a randomized complete block design (RCBD) with four replications.

At 30 and 60 days after sowing (DAS), Weed density were recorded and after 60 (DAS) weed density and biomass were recorded from four randomly selected quadrates (0.25×0.25 m) of each sub plot record the number of weeds, converted to number of weeds per $m^2$ and then averaged.. Dry weight of weeds was recorded after drying in an oven at 75°C for 72 h.

Mung bean plants were harvested at physiological maturity. Ten plants from each plot of mung bean were randomly selected. Dry weight biomass at 70°C for 48 h, number of pods per plant, number of seeds per pod, weight of 100-seeds and seeds yield/ha were recorded following standard procedure and then averaged.

The experiment was laid out in randomized complete block design (RCBD) with four replications. The collected data were statistically analyzed using analysis of variance (ANOVA) by GENSTAT computer software package. Differences among treatment averages were compared using Least Significant Differences (L.S.D.) ≤ 0.05 probability level [18].

**Total phenolics dynamics in the field soil**

Soil samples were taken from soil of plots of all treatments except weed free to a depth of 30 cm at 0, 14, 28 and 42 DAS. The soil of each sample was mixed thoroughly and allowed to dry at room temperature for 3 days [19]. Samples of 250 g dry soil were extracted separately in 250 ml of distilled water by shaking for 24 h at 200 rpm using electrical shaker [20]. Soil suspensions were filtered through Whatman No.2 filter paper under vacuum. Folin-Denis (0.5 ml) and $Na_2CO_3$ (one ml) were added to one ml of soil water extract and left to stand for 30 minutes. Absorbance was determined at 750 nm by aspectrophotometer [21].Total phenolic content was determined by standard curve using different concentrations of ferulic acid.

**Residues bioassay at different periods of decomposition**

This assay was basically run to test if the phenolics released from decomposed sorghum residues is responsible for the inhibition of weeds in mung bean crop. Soil samples were taken biweekly from plots amended with sorghum residues at10 t $ha^{-1}$, plots with 100 % Herbicide, plots with sorghum residues at 10 t $ha^{-1}$ + 60 % herbicides and zero residues and herbicides as control at a depth of 30 cm of field trial experiment and packed in plastic pots of 250 kg capacity. Twenty seeds of *Portulaca oleracea* (L.) were sown separately in their respective pots and watered with appropriate amount of water. All pots were placed under greenhouse conditions and distributed in randomized complete block design with 3 replications. Ten day s after sowing, seedling emergence was counted. Total dry weight of pigweed was determined after oven drying the plants at 70° C for 3 days. The weight was measured using an electrical balance.

**Results and discussion**

**Weed population density and dry biomass**

Weed flora dominated the mung bean field during the study comprised mainly of *Sorghum halepense* L., *Portulaca oleracea* L., *Convolvulus arvensis* L., *Echinochloa colonum* (L.) Link, *Glyccerhiza glabra* L. *Cynodon dactylon* L., *Malva rotundifolia* L.

All treatments significantly averted weed density over control at 30 days after sowing (DAS). Incorporation of sorghum residues (Enkath) in field soil at 5 and 10 t $ha^{-1}$ significantly reduced weed population density by16.9 and 30 % over control. However, this reduction is further increased when the lower rate of herbicide was applied to plots amended with sorghum residues. Combination of lower rate of trifluralin 30% and sorghum residues at 5 t $ha^{-1}$ and 10 t $ha^{1}$ significantly suppressed weeds density by 23.2 and 49.6 % over control, respectively, while combination of reduced trifluralin 60% and sorghum residues at 5 t $ha^{-1}$ and 10 t $ha^{-1}$ significantly reduced weeds density by 41.1 and

65.3% over control. Label rate of trifluralin (2.4 L $ha^{-1}$) recorded the highest inhibition of total weeds number by 69.7% over control table -1.

**Table 1-** Effect of different rates of sorghum residues cv. Enkath alone or in combination with reduced rates of trifluralin herbicide on population density of weeds in mung bean field at 30 days after sowing (DAS).

| **Treatments*** | **Weed population (Plant/$m^2$)** | **Reduction (% of control)** |
|---|---|---|
| Weedy check (control) | 61.2 | ----- |
| Residues at 5 t $ha^{-1}$ | 50.8 | 16.9 |
| Residues at 10 t $ha^{-1}$ | 42.8 | 30.0 |
| Residues at 5 t $ha^{-1}$ + 30% label rate of trifluralin | 47.0 | 23.2 |
| Residues at 5 t $ha^{-1}$ + 60%label rate of trifluralin | 36.0 | 41.1 |
| Residues at 10 t $ha^{-1}$ + 30%label rate of trifluralin | 30.8 | 49.6 |
| Residues at 10 t $ha^{-1}$ + 60%label rate of trifluralin | 21.2 | 65.3 |
| Label rate of trifluralin (2.4 L $ha^{-1}$) | 18.5 | 69.7 |
| L.S.D. ≤ 0.05 | 8.5 | ----- |

*Each number is an average of four replicates (Plots).

At 60 DAS, all treatments significantly inhibited weed density and dry biomass over control. Incorporation of sorghum residues (Enkath) in field soil at 5 and 10 t $ha^{-1}$ reduced weed population by 18.8 and 30.5 % over control and weed dry biomass by 23.3 and 34.4% over control. However, combination of the lower rates of herbicide with sorghum residues showed more suppression to weeds than sorghum residues applied alone. Combination of lower rate of trifluralin 30% and sorghum residues at 5 t $ha^{-1}$ and 10 t $ha^{-1}$ significantly reduced weeds density by 20.6 and 41.4 % and weed dry biomass by 38.8 and 63.0 % over control, respectively, while combination of reduced trifluralin 60% and sorghum residues at 5 t $ha^{-1}$ reduced weeds density by 37.0 % and weeds biomass by 52.2 % over control. The highest suppression of weed population and dry biomass was achieved by application of reduced rate of trifluralin (60%) to plots amended with sorghums residues at 10 t $ha^{-1}$. Interestingly, this treatment provides weed suppression statistically similar to that achieved by the label rate of trifluralin herbicide table -2.

**Table 2-** Effect of different rates of sorghum residues cv. Enkath alone or in combination with reduced rates of trifluralin herbicide on population density and dry biomass of weeds in mung bean field at 60 days after sowing.

| Treatments* | Total number of weeds/$m^2$ | Reduction (% of control) | Dry weight (g/$m^2$) | Reduction (% of control) |
|---|---|---|---|---|
| Weedy check (Control) | 92.2 | ------- | 393.7 | ----- |
| Residues at 5 t $ha^{-1}$ | 74.8 | 18.8 | 301.8 | 23.3 |
| Residues at 10 t $ha^{-1}$ | 64.0 | 30.5 | 258.2 | 34.4 |
| Residues at 5 t ha-1 + 30% label rate of trifluralin | 73.2 | 20.6 | 240.8 | 38.8 |
| Residues at 5 t ha-1 + 60% label rate of trifluralin | 58.0 | 37.0 | 188.0 | 52.2 |
| Residues at 10 t $ha^{-1}$ + 30% label rate of trifluralin | 54.0 | 41.4 | 145.5 | 63.0 |
| Residues at 10 t $ha^{-1}$ + 60% label rate of trifluralin | 31.0 | 66.3 | 82.5 | 79.0 |
| Label rate of trifluralin (2.4 L$ha^{-1}$) | 33.5 | 63.6 | 91.0 | 76.8 |
| LSD. ≤ 0.05 | 9.2 | ------- | 57.17 | ------- |

*Each number is an average of four replicates (Plots)

**Seeds and biological yields**

Both herbicide and residues applications and their interactions significantly affected seeds and biological yields over control table -3. Incorporation of sorghum residues into field soil at 5 and 10 t $ha^{-1}$ increased seeds yield by 36.9 and 51.2% of control and biological yield by 35.3 and 49.4% of control, respectively. However, integration of sorghum residues at 5 and 10 t $ha^{-1}$ and reduced rate of trifluralin (30%) increased seeds yield by 32.3 and 37.0 % and biological yield by 31.7and 36.3% over sole application of sorghum residues at 5 and 10 t $ha^{-1}$, respectively. Integration of sorghum residues at 5 t $ha^{-1}$ and reduced rate of trifluralin 60% increased seeds yield by 42.8% and biological yield by 41.6 % over sole application of sorghum residues at 5 t $ha^{-1}$. However, integration of sorghum residues at 10 t $ha^{-1}$ and reduced rate of herbicide 60% produced maximum seeds yield (2.85 t $ha^{-1}$) and biological yield (9.3 t $ha^{-1}$) which was 24.9 and 21.7 % higher than the label rate of herbicide, while weedy free treatment increased seed yield 12.6% and biological yield by 10.5% over label rate of trifluralin (2.4 L $ha^{-1}$).

**Table 3-** Effect of different rates of sorghum residues cv. Enkath alone or in combination with reduced rates of trifluralin herbicide on seeds and biological yields of mung bean.

| Treatments* | Seeds yield(t/ha) | Biological yield (t/ha) |
|---|---|---|
| Weedy check (control) | 0.58 | 2.14 |
| Residues at 5 t $ha^{-1}$ | 0.92 | 3.31 |
| Residues at 10 t $ha^{-1}$ | 1.19 | 4.23 |
| Residues at 5 t $ha^{-1}$ + 30% of label rate of trifluralin | 1.36 | 4.85 |
| Residues at 5 t $ha^{-1}$ + 60% of label rate of trifluralin | 1.61 | 5.67 |
| Residues at 10 t $ha^{-1}$ + 30% of label rate of trifluralin | 1.89 | 6.65 |
| Residues at 10 t $ha^{-1}$ + 60% of label rate of trifluralin | 2.85 | 9.39 |
| Weedy free | 2.45 | 8.22 |
| Label rate of trifluralin (2.4 L $ha^{-1}$) | 2.14 | 7.35 |
| LSD $\leq$ 0.05 | 0.50 | 1.63 |

*Each number is an average of four replicates (Plots).

**Yield components**

Number of pods per plant was significantly affected by sorghum residues incorporated into the field soil and their interactions with the reduced rates of herbicides table 4. Incorporation of sorghum residues at 5 and 10 t $ha^{-1}$ into the field soil markedly increased number of pods by 18 and 26.4% over control, respectively. However, application of sorghum residues at 5 and 10 t $ha^{-1}$ in combination with 30% of full rate of trifluralin increased number of pods by 33.3 and 42.5% over control, respectively. Incorporation of sorghum residues at 5 t $ha^{-1}$ with 60% of full dose of trifluralin increased number of pods by 37.5% of control. Maximum increases (13.1 pods/plant) was recorded in treatment 10 t $ha^{-1}$ + 60% rate of trifluralin followed by weedy free treatment (12.4 pods/plants) then label rate of trifluralin (9.2 pods/plants).

All treatments including control recorded no significant differences in the number of seeds per pods table 4. However, label rate of herbicide and sorghum residues at 10 t $ha^{-1}$ in combination with 60% of trifluralin treatments recorded the least number of seeds per pod.

Weight of 100 - seed was significantly increased by 38.6% and 43.1% over control by application of full rate of trifluralin and weedy free treatments table 4. Incorporation of sorghum residues at 5 t $ha^{-1}$ and 10 t $ha^{-1}$ in to the soil significantly increased weight of 100 seeds by 12.9 and 16.9% over control respectively. However, incorporation of sorghum residues into field soil at 5 and 10 t $ha^{-1}$ amended with the 30% label rate of trifluralin increased weight of 100 seeds by11.4 and 22.6% over sole application of sorghum residues at 5 and 10 t $ha^{-1}$. Incorporation of sorghum residues in to field soil at 5 t $ha^{-1}$ amended with the 60% of the full rate of trifluralin increased the weight of 100 seeds by 30.7% over control. Maximum increase was recorded by the treatment of sorghum residues at 10 t $ha^{-1}$ + 60% rate of trifluralin by 47.0% over control and by 13.7 % of label rate of trifluralin (2.4 L $ha^{-1}$), respectively.

**Table 4**- Effect of different rates of sorghum residues cv. Enkath alone or in combination with reduced rates of trifluralin herbicide on yield components of mung bean.

| Treatments* | Number of pods per plants | Number of seeds Per pod | Weight of 100 seeds(g) |
|---|---|---|---|
| Weedy check (Control | 5.0 | 12.1 | 5.7 |
| Residues at 5 t ha$^{-1}$ | 6.1 | 12.3 | 6.2 |
| Residues at 10 t ha$^{-1}$ | 6.8 | 12.5 | 6.5 |
| Residues at 5 t ha$^{-1}$ + 30% label rate of trifluralin | 7.5 | 12.5 | 6.4 |
| Residues at 5 t ha$^{-1}$ + 60% label rate of trifluralin | 8.0 | 12.6 | 6.6 |
| Residues at 10 t ha$^{-1}$ + 30% label rate of trifluralin | 8.7 | 12.5 | 7 |
| Residues at 10 t ha$^{-1}$ + 60% label rate of trifluralin | 13.1 | 9.5 | 7.8 |
| Weedy free | 12.4 | 12.3 | 7.7 |
| Label rate of trifluralin (2.4 L ha$^{-1}$) | 9.2 | 9.3 | 7.3 |
| LSD ≤ 0.05 | 3.2 | N.S | N.S |

*Each number is an average of four replicates (Plots).

**Total phenolics**

Total phenolics in field soil significantly increased after incorporation of sorghum residues at 10 t ha$^{-1}$ and reached their peak at 4 weeks of residues decomposition, then decreased significantly at 6 weeks and vanished at 6 weeks figure -1.

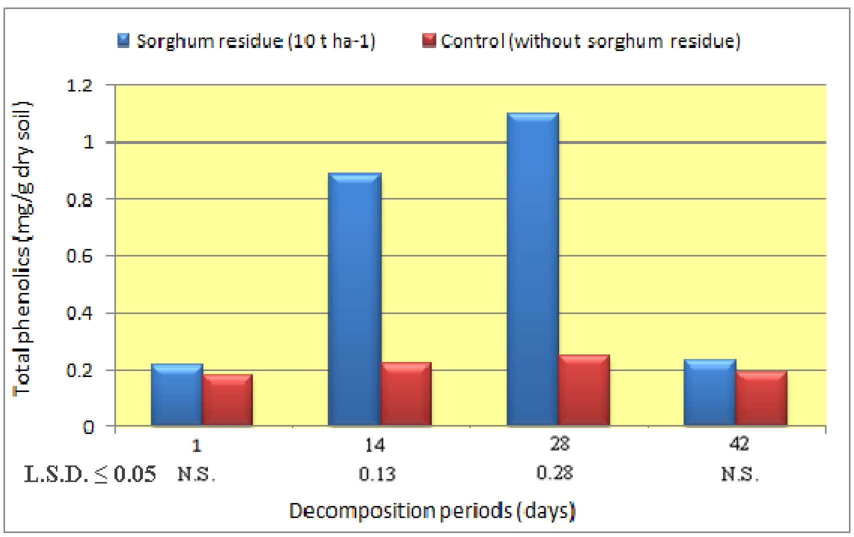


**Figure 1**-Total phenolics release in field soil amended with sorghum residues at 10 t ha$^{-1}$ during different decomposition periods. Each value is an average of four replicates.

**Residues bioassay at different periods of decomposition**

All treatments significantly suppressed seedling emergence of *Portulaca oleracea* over weedy check at all decomposition periods compared to the weedy check treatment table 5. In all treatments, the highest inhibition was recorded during the 4 and 6-week decomposition periods. Application of 60% of full rate of herbicide suppressed weed emergence by 44.3, 50.4 and 40.6% over their respective sole application of sorghum residues at 2, 4 and 6-week decomposition periods, respectively. Interestingly, integration of reduced rate of herbicide and the residues rate provide suppression of seedling emergence more than that achieved by sole application of label rate of herbicide in most of the test decomposition periods.

**Table 5-** Effect of *Sorghum bicolor* cv. Enkath residues at 10 t $ha^{-1}$ in combination with 60% of full rate of trifluralin on seedling emergence of *Portulaca oleracea* .

| Treatments* | % of Seedling emergence | | | |
|---|---|---|---|---|
| | Decomposition Periods (Week) | | | |
| | 2* | 4 | 6 | 8 |
| Weedy check (Control) | 78.8 | 70.2 | 67.5 | 82.0 |
| Residues at 10 t $ha^{-1}$ | 41.0 | 24.2 | 29.5 | 45.0 |
| Residues at 10 t $ha^{-1}$ + 60% of label rate of trifluralin | 22.8 | 12.0 | 17.5 | 44.8 |
| Label rate of trifluralin (2.4 L $ha^{-1}$) | 15.8 | 21.5 | 27.7 | 51.2 |
| L.S.D ≤ 0.05 | 7.2 | 5.7 | 6.1 | 7.7 |

*Each number is an average of four replicates.

The results also revealed that seedling growth of *Portulaca oleracea* was significantly suppressed over control by all treatments at all decomposition periods table 6. Sorghum residues incorporated into field soil suppressed dry weed biomass by 65.8, 84.6, 70.2 and 51.4% over their respective control at 2, 4, 6 and 8 week decomposition periods, respectively. The suppression of weed is further increased when sorghum residues is incorporated in to field soil amended with 60% of full rate of trifluralin herbicide. Combination of sorghum residues with 60% of label rate of herbicide suppressed weed dry biomass by 56.3, 24.2, and 33.9% over their respective sole application of sorghum residues at 2, 4, and 6 weeks decomposition period, respectively. Moreover, this combination provide weed suppression higher than that achieved by label rate of herbicide at all decomposition periods except the first one where the highest weed suppression was recorded by the label rate of the herbicide.

**Table 6**- Effect of *Sorghum bicolor* cv. Enkath residues at 10 t $ha^{-1}$ in combination with 60% of full rate of trifluralin on seedling dry weight biomass of *Portulaca oleraceae.*

| Treatments | Plant dry weight biomass (mg) | | | |
|---|---|---|---|---|
| | Decomposition Periods (Week) | | | |
| | 2* | 4 | 6 | 8 |
| Weedy check (Control) | 101.8 | 86.0 | 72.2 | 97.8 |
| Residues at 10 t $ha^{-1}$ | 34.8 | 13.2 | 21.5 | 47.5 |
| Residues at 10 t $ha^{-1}$ + 60% of label rate of | 15.2 | 10.0 | 14.2 | 41.5 |
| Label rate of trifluralin (2.4 L $ha^{-1}$) | 8.5 | 17.0 | 24.5 | 84.0 |
| L.S.D ≤ 0.05 | 3.8 | 2.2 | 11.6 | 7.7 |

*Each number is an average of four replicates

Analysis of the data of the present work revealed that sorghum residues incorporated into the field soil inhibited population density and dry biomass of weeds and the suppression magnitude achieved was proportional to incorporated sorghum residues rate. The reduction in weed density and biomass seems an outcome of inhibitory effects exerted by sorghum residues. Such a reduction is believed to originate by the release of phytotoxic allelochemicals from sorghum residues in the immediate vicinity during their decomposition [22].This result confirms the earlier work of [23], who reported that sorghum residues incorporated into the field soil at 10 t $ha^{-1}$ reduced weed population and dry weight biomass in mung bean up to 42and 51 % of control, respectively. Subsequent experiment proved that the suppression of weeds was due to the total phenolics released during decomposition of sorghum residues in soil since a high correlation ($R^2$ = 0.95and 0.87) was found between the total phenolics and the % of seedling emergence and dry biomass of the test weed respectively table-5 & 6. No attempt was made to identify the allelochemicals responsible for weed suppression in the phenolics. However several investigators [17] were able to isolate and identify several phenolics acids, namely protocatechuic acid, p-hydroxyl benzoic acid, vanillic acid, syringic acid, p-coumaric acid, ferulic acid, caffeic acid, catechol acid and gallic acid from the soil containing sorghum cv. Enkath residues and these phenolics reached their maximum peak at 4$^{th}$ weeks and vanished at 2$^{nd}$ month from incorporation of residues in to the field soil. These phytotoxins are reported to have inhibitory effects on several processes such as inhibition of chlorophyll biosynthesis, respiration, photosynthesis, ions uptake, hormones biosynthesis and cell division, inhibition of the activity of some enzymes involved in essential metabolic processes and others [24-26]. Furthermore, these allelochemicals are water soluble and when imbibed by the germinating weed seeds, can hamper their germination and subsequent seedling growth, thus contributing to overall decline in the density, vigor and stand establishment of the overall weed community [27]. Greater weed inhibition was observed at higher residue incorporation rates. [28,29] pointed out that suppression magnitude in allelopathic interactions is directly proportional to the applied dose of an allelopathic product.

It is noteworthy to mention that the period indicating maximum quantities of phenolics coincided with the period in which maximum suppressive activity against weeds was noticed under field conditions. This could explain why poor growth of weeds was observed during this period in the mung bean field, and then start to grow thereafter. However, at that time mung bean plants become highly competitive to weeds. The poor growth of weeds of different crops after incorporation of allelopathic residues of sorghum and sunflower into field soil was also reported by several investigators [30,31].

Although sorghum residues showed significant reduction to weed population density and dry weight biomass, their efficacy could not comparable with that of the label rate of trifluralin herbicide. This result is in accordance with several investigators who reported that the efficacy of allelopathic crop residue was below that of commercial herbicides [6]. However, when herbicide application at 60% of label rate was applied to plots amended with higher rate (10 t $ha^{-1}$) of sorghum residues, a similar or even greater weed suppression than sole application of herbicide was recorded table -2. These results confirmed hypothesis proposed by [7] that lower dose of herbicide applied in combination with allelopathic conditions could enjoy a complementary interaction and may help to minimize herbicide usage for weed management in field crops. Also, these results are in line with those obtained by [15] who reported similar suppression of weed population and biomass in faba bean with sorghum residues when applied in combination with reduced rate of trifluralin. Furthermore, [19] found that combined sunflower residues and reduced rate (50% of full dose) of chevalier herbicide were effective as the label rate of herbicide in suppression weed density and dry weight in wheat field. It seems from these results that a reduced level of trifluralin herbicide is feasible for providing satisfactory weed control when it works simultaneously with allelopathic conditions.

The increase of mung bean dry biomass and seed yield by application of sorghum residues alone and in combination with reduced herbicide rate over weedy check treatment seems an outcome of reduced weed – crop competition for any of the growth factors which might have contributed to higher yield and biomass. By Minimizing competition due to better weed control, mung bean plants uptake more water and nutrients that resulted in vigorous growth and seed yield. Furthermore, incorporation of sorghum residues into the field soil improved physical, chemical and biological properties of soil and this could explain why the higher rate (10 t $ha^{-1}$) of sorghum residues along with reduced (60% of full dose) rate of trifluralin herbicide showed better yield and dry biomass of mung bean than sole application of label rate of trifluralin. There are many earlier reports available that signify the role of reduced doses of commercial herbicides in combination with allelopathic plant residues to enhance grain and biological yield [12,31,15]. Apparently, the higher grain yield by all the test treatments was attributed to improve number of pods per plant and 100 – seed weight. Many researchers have stressed the need for decreasing the use of herbicides in crop production. Residues of the allelopathic plants can serve as the means of using allelopathy for practical weed management. Use of allelopathic crop residues and reduced rates of herbicides have been effective for weed management in field crops, such as faba bean, barley and wheat [31,12]. [6] reviewed the practical implications of the various strategies which can be used for allopathic weed control in crops.

Finally, the present study revealed that sorghum residues used with 60% of full rate of trifluralin herbicide is highly effective approach in controlling weeds in mung bean field, improving seeds yield of mung bean crop and increasing environmental safety by reducing reliance on synthetic herbicides on other hand.

## References


1. Olofsdotter, M. **1998**. Allelopathy in rice. *In* M. Olofsdotter (ed.), Proceeding of the Workshop on Allelopathy in Rice, 25-27 Nov. 1996. Manila, Phillippines, International Rice Research Institute, pp. 1-5.
2. Rice, E. L. **1984**. *Allelopathy*. Second Edition. Academic Press , Orlando, Florida, USA,.

3. Singh, H. P., Batish, D. R. and Kohli, R. K. **2001**. Allelopathy in agroecosystems: an overview. *Journal of Crop Protection* (4),pp:1- 41
4. Weston, L. A., and Duke, S. O. **2003**. Weed and crop allelopathy. *Critical Review of Plant Science* (22),pp:367 – 389.
5. Alsaadawi, I. S. and Dayan, F. E. **2009**. Potential and prospects of sorghum allelopathy in agroecosystems. *Allelopathy journal* (24),pp: 255-270.
6. Weston, L. A., Alsaadawi, I. S. and Bearson, S. C. **2013**. Sorghum allelopathy from ecosystem to molecule. *Journal of Chemical Ecology* (39),pp: 142-153.
7. Bhowmik, P. C. and Inderjit, A. **2003**. Challenges and opportunities in implementing allelopathy for natural weed management. Journal of *Crop Protection* (22),pp: 661-671.
8. Cheema, Z. A., Farid, M. S. and Khaliq, A. **2003**a. Efficacy of concentrated sorgaab with low rate of atrazine for weed control in maize. *Journal of Animal and plant Sciences* (13),pp: 48-51.
9. Cheema, Z. A., Khaliq, A. and Farooq, R. **2003**b. Effect of concentrated sorgaab alone and in combination with herbicides and surfactant in wheat. *Journal of Animal and plant Sciences* (13),pp: 48-51
10. Cheema, Z. A., Khaliq, A. and Hussain, R. **2003**c. Reducing herbicides rate in combination with allelopathic sorgaab for weed control in cotton . *International Journal of Agriculture and Biology* (5),pp: 4-6.
11. Iqbal, J., Cheema, Z. A. and Mushtaq, M. N. **2009**. Allelopathic crop water extracts reduce the herbicide dose for weed control in cotton (*Gossypium hirsutum*). *International Journal of Agricultural and Biology* (11),pp: 360-366.
12. Alsaadawi, I. S. and Al-Temimi, A. A. **2011**. Use of sunflower residues in combination with sub-recommended dose of herbicides for weeds control in barley field. *Academic Journal* (12),pp:83-93.
13. Alsaadawi, I. S., Khaliq, A., Al-Timimi, A. A. and Matloob, A.O. **2011**. Integration of sunflower (*Helianthus annus* L.) residues with a pre-plant herbicide enhances weed suppression in broad bean (*Vicia faba* L.) fields. *Journal Planta Daninha* (29),pp: 849-859.
14. Lahmood, N. R. and Alsaadawi, I. S. **2014**. Weed control in wheat using sorghum residues and less herbicide. *Allelopathy Journal* (34),pp: 277-286.
15. Alsaadawi, I. S., Khaliq, A., Lahmod, N. R. and A. Matloob **2013**. Weed management in broad bean (*Vicia faba* L.) through allelopathic *Sorghum bicolor* (L.) Moench residues and reduced rate of a pre-plant herbicide. *Allelopathy Journal* (32),pp:203-212.
16. Hamdan, M. I. **2006**. Guidance in the cultivation and production of *Sorghum bicolor* (L.) Moench. Newsletter No. 19, State Board of Extension and Agricultural Cooperation, Ministry of Agriculture, Iraq.
17. Alkhateeb, T. A. A. **2014**. Allelopathic potential of two sorghum cultivars on weeds, mung bean and symbiotic nitrogen fixation and possible rapid identification of allelopathic potential by PCR technique. Ph. D. thesis, College of Science, University of Baghdad, Iraq.
18. Steel, R. G. D., Torrie, J. H. and Dickey, D. **1997**. *Principles and Procedures of Statistics*: *A Biometrical Approach*. Third Edition. McGraw -Hill Book Co. Inc., *New York, USA*. pp. 172-177.
19. Nsayef, S. M., Alsaadawi, I. S. and Aboud , H. M. **2014**. Integrated effect of different rates of sunflower residues and chevalier on weeds of wheat crop and associated mycorrhiza. *Iraqi . Journal of Agriculture.* (19),pp: 94–102.
20. Ben - Hammouda, M., Robert, J. K., Harry, C. M. and Sarwar, M. **1995**. A Chemical basis for differential allelopathic potential of sorghum hybrids on wheat. *Journal of Chemical ecology* (21),pp: 775-786.
21. Blum, U., Wentworth, T. R., Klein, A. D.,King, L. D., Gerig, T. M. and Lyu, S.W. **1991**. Phenolic acid content of soils from wheat-no till, wheat-conventional till and fallow-conventional till soybean cropping systems. *Journal of Chemical Ecology,* (17),pp: 1045-1067.
22. Birkett, M. A., Chamberlain, K., Hooper, A. M. and Pickett J. A. **2001**. Does allelopathy offer real promise for practical weed management and for explaining rhizophere interactions involving higher plants. *Plant and Soil* (232),pp: 31-39.
23. Alsaadawi I. S., Alkhateeb, T.A., Hadwan, H. A. and Lahmood N. R. **2015**. A chemical basis for differential of allelopathic potential of root exudates of *Sorghum bicolor* L. (Moench) cultivars on companion weeds. *Journal of Allelochemical Interactions* (1),pp: 49-55.

**24.** Hejl, A. M., Einhellig, F.A. and Rasmussen, J.A. **1993**. Effects of juglone on growth, photosynthesis and respiration. *Journal of Chemical. Ecology* (19),pp: 559-568.

**25.** Weir, T. L., Sang-Wook, P. and Vivanco, J. M. **2004**. Biochemical and physiological mechanisms mediated by allelochemicals. *Current Opinion in Plant Biology* (7),pp:472–479

**26.** Politycka, B. and Gmerek, J. **2008**. Effects of ferulic and *p*-coumaric acids on the activity of hydrolytic enzymes and the growth of radicles in germinating seeds of cucumber and pea. *Allelopathy Journal* (21),pp: 227-238.

**27.** Gallandt, E. R., Liebman M., and Huggins D.R. **1999**. Improving soil quality: implications for weed management. *Journal of Crop Production* (2),pp: 95-121.

**28.** Khanh, T. D., Chung, M. I., Xuan, T. D. and Twta, S. **2005**. The exploitation of crop allelopathy in sustainable agricultural. *Journal. Agronomy. Crop Sciences*, (191),pp: 172-184.

**29.** Khaliq A., Matloob, A., Cheemam Z. A. and Farooq, M. **2011**. Allelopathic activity of crop residue incorporation alone or mixed against rice and its associated grass weed jungle rice (*Echinochloa colona* L. Link). *Chilean Journal of Agricultural Research* (71),pp: 418-423

**30.** Al-Temimi, A. O. **2010**. Effect of interaction of sunflower residues and herbicides on weeds and barley crop. M.Sc. thesis, College of Science, University of Baghdad, Iraq.

**31.** Al-Bedairy, N. R., Alsaadawi, I. S. and Shati, R. K. **2011**. Effect of combination of *Sorghum bicolor* L. (Moench) residues and trifluralin herbicide on broad bean and its weeds. *Iraqi Journal of Agriculture* pp:94-102