ECONOMIC ASSESSMENT OF CROP RESIDUES AND SULFUR APPLICATION FOR IMPROVING YIELD AND QUALITY OF SESAME UNDER SEMI-ARID ENVIRONMENT

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ABSTRACT

A field experiment was conducted to investigate the effects of crop residue (CR) and sulfur (S) on the sesame yield, oil contents and net economic return at Agronomy Research Farm, The University of Agriculture Peshawar, during kharif season 2015. Treatments were consisted of four levels of residues [sole wheat residues (4 t ha-1), sole chickpea residues (2 t ha-1), wheat plus chickpea residue (4+2 t ha-1) and wheat plus chickpea residue (2+1 t ha-1)] and four levels of sulfur (15, 30, 45, 60 kg ha^{-1}) along with one control for both crop residue and sulfur. Results indicated that crop residues and sulfur application significant effected yield and quality attributes of sesame. Plots treated with 4+2 t ha^{-1} checkpea+wheat residues produced taller plants (180.5 cm) with higher seeds capsule^{-1} (61), 1000-seed weight (3.74 g), biological yield (4014 kg ha^{-1}), seed yield (818 kg ha^{-1}), harvest index (20.40%) and more percent oil contents (43.83%) and oil yield (359 kg ha^{-1}), which was statistically similar with sole 2 t ha-1 chickpea residues incorporation. Likewise, 45 kg ha-1 sulfur fertilization resulted in taller plants (181.0 cm), higher seeds capsule^{-1} (65), 1000-seed weight (3.93 g), biological yield (4036 kg ha^{-1}), seed yield (833 kg ha^{-1}), harvest index (20.65%), percent oil contents (46.54 %) and oil yield (388 kg ha^{-1}) as compared to the rest of the levels. Economic analysis indicated that application of 2 t ha-1 sole chickpea residues along with 45 kg ha-1 sulfur resulted in higher value cost ratio (VCR) (4.26) and net income (Rs. 175814). Conclusively, 2 t ha^{-1} sole chickpea residues incorporation and 45 kg ha^{-1} sulfur application boosted sesame yield, oil contents, and net economic return and hence are recommended for improved sesame productivity. However, long term research are still needed to be carried out under different environmental and soil conditions to address the low yield issues and help farmers boost their yield on sustainable basis.

Keywords: Crop residue, chickpea residues, fertilization, sustainable basis.

INTRODUCTION

Legumes, mostly are comprised of higher phosphorus have the ability to utilize soil phosphorus and contain inferior C:P ratios as compared to cereal residues, favoring net P mineralization. Legume residues incorporation provide mineralized N to the principal crops (Motior *et al.,* 2009) and protect uncovered soil against erosion losses in the warm tropical and semi-arid climate. Removal of crop residue through burning not only decrease soil nutrients but also eliminates carbon from the soil as well as organic matter. Soil organic matter and carbon in the soil are significant for enhancing soil life and serve as feed for different microorganisms (Blanco-Canqui and Lal, 2009). Residues removal from the field increases the chances of erosion which have the negative effect on environment (Lal, 2004 and Johnson *et al.,* 2010). Therefore, incorporation of crop residue to soil can contribute to increase nutrients for maximum crop production (Johnson *et al.,* 2010; Delgado *et al.,* 2007) and have the potential to reduce soil erosion (Lal, 2000). Crop residue incorporation increases organic carbon in the soil and nitrogen (Al-sheikh *et al.,* 2005; Ghimire *et al.,* 2012).

For enhancing sesame production fertilizer management is one of the most important factors but due to the high price of chemical fertilizers small farmers cannot afford its application in sufficient quantity which results in less productivity (Ahmad, 2000). In these situations, integrated use of synthetic and organic fertilizers can play significant role in sustaining health of soil as well as higher crop production (Tandon, 1998; David *et al.,* 2003). Crop residues contain cellulose, hemi-cellulose, water soluble materials and proteins, comprising nitrogen and sulfur mineral elements. Legumes retain nutrients in its residue with nitrogen and phosphorus at 25 %, sulfur at 50 % and potassium at 75% making them valuable nutrient sources. Incorporation of legume residues not only improves the soil health and enhance nitrogen (N) content, but also elevate phosphorus supply to the crop (Kabir and koide, 2002). The residue chemistry and environmental attributes i.e. soil moisture, are important factors that affect the decomposition rate and release of nutrients. Residues having more phosphorus (P) content usually decompose quickly and discharge more P within a small interval (Tian *et al.,* 1992).

Sulfur (S) is the fourth macro nutrient after nitrogen, phosphorus and potassium. In general the S uptake by crops is just marginally less than uptake of P, but in case of oilseed crops, S uptake can exceed than that of P. Sulfur is directly involved in several metabolic and enzymatic processes of plants and is also an important component of glutathione which plays an imperative role in plant respiration. Sulfur and iron application improve growth, yield, yield component and nutrient uptake of sesame (Heidari *et al.,* 2011). Sulfur plays an important function in development and quality of oil seed crops. That is why oilseed crops needs a greater amount of sulfur for more oil yield (Salwa *et al.,* 2010). Jamal *et al*. (2010) stated that sulfur is a vital part of proteins, glucosinolates and some other constituents that determines the quality of oilseed crops. Ghosh *et al.* (2002) and Raja *et al.* (2007) reported that Indian sub-continent soils are deficient of sulfur and crops required fertilization of sulfur. There is a synergetic relationship between nitrogen and sulfur metabolism. Sulfur application considerably improves the nitrogen contents in straw and seed (Fazli *et al.*, 2008) thus enhances the seed yield. Maximum seed yield of oil seed crop could be achieved by applying sulfur and nitrogen in equilibrium due to their synergetic relationship (Fazli *et al.,* 2010). Keeping in view the importance of crop residues and sulfur, the current study was conducted to evaluate the performance of sesame under various levels of crop residues and sulfur.

MATERIALS AND METHODS

Field experiment was carried out at Agronomy Research Farm, The University of Agriculture Peshawar during kharif 2015. The design of the experiment was randomized complete block with four replications. Treatments were consisted of four levels of residues [sole wheat residues (4 t ha-1), sole chickpea residues (2 t ha-1), wheat plus chickpea residue (4+2 t ha-1) and wheat plus chickpea residue (2+1 t ha-1)] and four levels of sulfur (15, 30, 45, 60 kg ha^{-1}) along with one control for both crop residue and sulfur. Treatments structure of the experiment is given in Table 1. Field was irrigated on 14^{th} June 2015 and land was prepared on 20^{th} June 2015 by incorporating residues and sulfur with help of cultvator. Sowing was done on 21^{th} June 2015. Sesame black variety with seed rate of 5 kg ha^{-1} was sown. Row to row distance 60 cm, with 5 rows and plot size of 3 m x 3 m was used. Nitrogen with the rate of 100 kg ha^{-1} at two splits (half does was applied at the time of sowing and half was applied at knee height), Phosphorus as P_2O_5 was applied as basal does with the rate of 30 kg ha^{-1} at sowing time. Sulfur source was ammonium sulfate.

Uniform agronomic practices were carried out throughout the growing season for all experimental plots. First irrigation was given after 9 days of sowing for uniform emergence. Further irrigations were applied according to weather condition as and when needed. Weeds were control manually by hoeing. Crop matured in 109 days and harvested on 8 oct 2015.

Data collection

Biological yield components

Plant height (cm) was measured from bottom to the tip of the sesame plant with the help of measuring tap. Height of five randomly selected plants was measured in each plot when plants ceased to grow and was averaged. Biological yield was calculated by harvesting three central rows in each treatment. The harvested plants were tied into bundles and were dried in sun and weighted by sensitive electronic balance which was then converted into kg ha^{-1}.

Economical yield components

Seeds $capsule^{-1}$ was counted at 80% maturity before harvesting. Ten capsules were selected randomly form the plants of each plot and then seeds were counted in every capsule and then averaged. As per treatment, 1000 seeds were counted with help of grain counting machine and weighted with help of sensitive electronic balance to get 1000-seed weight. Seed capsules of the harvested three central rows for biological yield were sundried, threshed by hands and were weighed and converted into kg ha^{-1} seed yield. Harvest index was calculated as the ratio of seed yield into biological yield and expressed in percent (%).

Quality parameters

Oil percentage was determined by using Sox let Equipment and petroleum either (40-60°C) as an extraction solvent in chemistry laboratory at the University of Agriculture Peshawar. Oil yield (kg ha^{-1}) were recorded after oil extract (%) and converted into kg ha^{-1}.

Statistical analysis

Data were statistically analyzed by using analysis of variance techniques appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability, when the F-values were significant (Jan *et al.*, 2009).

RESULTS

Biological yield and yield components

Data regarding plant height and biological yield of sesame is presented in Table 3. Analysis of data indicated that crop residues (CR) and sulfur (S) had significantly affected plant height and biological yield of sesame, however the interaction between CR and S was found not significant (Table 2). Similarly the control vs rest difference was also found significant for both plant height and biological yield of sesame (Table 5). Mean data indicated that maximum plant height of 180.5cm were recorded in plots received combine application of chickpea+wheat residues at the rate of 4+2 t ha^{-1} which was statistically at par with the combine application of chickpea+wheat residues at the rate of 2+1 t ha^{-1} (178.4 cm) and sole chickpea residues (176.7 cm), while minimum plant height was recorded for sole wheat residue (170.8 cm). Similarly, maximum biological yield (4014 kg ha^{-1}) was recorded in the plots treated with wheat+chickpea residues at the rate of 4+2 t ha^{-1} which was statistically at par with sole chickpea residues (3913 kg ha^{-1}). However, minimum biological yield (3831 kg ha^{-1}) was recorded with incorporation of sole wheat residues. Regarding sulfur, Plots fertilized with 45 kg ha^{-1} S resulted in taller plants (181.0 cm) followed by application of S at the rate of 60 kg ha^{-1}, which was statistically similar with 30 kg ha^{-1} S fertilization. Short stature plants (171.8 cm) were produced with 15 kg ha^{-1} S application. Likewise, higher biological yield of 4023 kg ha^{-1} was noted with 45 kg S ha^{-1} which was statistically similar to sulfur at the rate of 60 kg ha^{-1}, while lower biological yield (3827 kg ha^{-1}) was recorded with 15 kg S ha^{-1} application. Fertilized plots produced taller plants (176.6 cm) and higher biological yield of sesame as compared to control plots (Table 5).

Economical yield components

Data regarding seeds capsule^{-1}, 1000-seed weight, seed yield and harvest index of sesame is given in Table 4. Analysis of data indicated significant effects of CR and S on economical yield components of sesame. However, the interaction between CR and S was found not significant (Table 2 & Table 4). Similarly, control vs. rest difference was also found significant for all the economical yield components of sesame (Table 5). Mean values of data showed higher seeds capsule^{-1} (62) and 1000-seed weight (3.74 g) with 2+4 t ha^{-1} wheat+chickpea residue amendment which was at par with 2 t ha^{-1} sole chickpea residues, while minimum seeds capsule^{-1} (53) and 1000-seed weight (2.89 g) were recorded with application of sole wheat residues at the rate of 4 t ha^{-1}. Regarding S fertilization, seed capsule^{-1} and 1000-seed weight increased with increasing S level up to 45 kg ha^{-1} while further increase in S application did not show any significant increase in seed capsule^{-1} and 1000-seed weight. However, lower seed capsule^{-1} (52) and 1000-seed weight (2.65 g) was recorded with 15 kg ha^{-1} S application. Integrated application of wheat+chickpea residues at the rate of 4+2 t ha^{-1} produced higher seed yield (818 kg ha^{-1}) and harvest index (20.4%) which was statistically similar to 2 t ha^{-1} sole chickpea residues amendment. However, minimum seed yield and harvest index of 736 kg ha^{-1} and 19.2% was recorded in plots where 4 t ha^{-1} sole wheat residues were applied. In case of sulfur, higher seed yield (831 kg ha^{-1}) and harvest index (20.65%) was observed with application of 45 kg S ha-1, while lower seed yield (722 kg ha^{-1}) and harvest index (18.89%) was recorded at lower level of sulfur i.e. 15 kg ha^{-1} application.

Planned mean comparison of the data showed that control plots in comparison with fertilized plots resulted in lower seeds capsule^{-1} (42), 1000-seed weight (2.1 g), seed yield (488 kg ha^{-1}) and harvest index (15.16%) of sesame (Table 5).

Sesame quality

Data regarding oil contents (%) and oil yield (kg ha^{-1}) of sesame is presented in Table 3. Analysis of data revealed that CR and S had significantly affected oil contents and oil yield of sesame, however the interaction between CR and S was found not significant for both oil contents and oil yield (Table 2). Similarly, the difference between control vs. rest was also found significant (Table 5). Mean data indicated that maximum oil content (43.83%) were recorded in plots amended with integrated chickpea+wheat residues at the rate of 4+2 t ha^{-1} which was statistically similar with application of 2 t ha^{-1} sole chickpea residues (43.36%), while minimum oil contents (42.08%) were recorded with 4 t ha^{-1} sole wheat residues incorporation. Similarly, plots treated with integrated 4+2 t ha^{-1} wheat+chickpea residues resulted in higher oil yield (359 kg ha^{-1}) which was statistically at par with sole chickpea residues at the rate of 2 t ha^{-1}. However, minimum oil yield (311 kg ha^{-1}) was recorded with incorporation of sole wheat residues. Regarding sulfur, plots fertilized with 45 kg ha^{-1} S yielded higher oil contents (46.54 %) and oil yield (387 kg ha^{-1}) of sesame, whereas lower oil contents and oil yield of 39.76% and 287 kg ha^{-1} were found with 15 kg S ha^{-1} application. Fertilized plots resulted in higher oil contents (42.97%) and oil yield (334 kg ha^{-1}) of sesame as compared to control plots (Table 5).

DISCUSSION

Effect of crop residues and sulfur on grain yield and biomass yield

Seed $capsule^{-1}$ were significantly affected by crop residues (CR), sulfur (S) and control vs rest, while interaction between (CR x S) was non-significant. Plots treated by combined application of wheat and chickpea residue (4+2 t ha^{-1}) produced significantly more seed $capsule^{-1}$ which was at par to sole chickpea residue and minimum capsule $plant^{-1}$ was observed in plots having no sulfur and crop residue. The reason might be that crop residue significantly improved vegetative growth as a result better portioning of assimilates towards sink, as a result number of seed $capsule^{-1}$ increased. Shehu et al. (2010) stated that application of nitrogen enhanced seed $capsule^{-1}$ as compared to control plots. Our results illustrated that number of seeds capsules $plant^{-1}$ were increased with each incensement of sulfur up to 45 kg ha^{-1} and more seeds $capsule^{-1}$ were recorded at 45 kg ha^{-1}, while lowest seeds $capsule^{-1}$ were counted in control plots (no sulfur). Sulfur application in ample amount helps in the development of floral primordial i.e reproductive parts, which results in the development of capsule and seeds in the plants (Verma *et al.,* 2014). These results are supported by Sarkar and Benik (2002) and Raja *et al.* (2007), who reported more seed capsule^{-1} with sulfur application as compared to no sulfur application to the sesame crop.

Data related to thousand seeds weight revealed that crop residues and sulfur had significantly affected thousand seeds weight while interactions between CR x S had no significant effect on thousand seeds weight. In case of crop residue combined application of wheat + chickpea residue (4+2 t ha^{-1}) produced significantly heaver seeds as compared to control plots having no crop residue. This might be due to that fact that nitrogen release from crop residue extended the vegetative growth, delay maturity and ultimately seed filling duration as a result heaver grains were produced. Our results were supported by Paul. (2013) who stated that net assimilation rate was maximum with millet husks at the rate of 6 t ha^{-1} which increased thousand seeds weight as compared with 3 t ha^{-1}. Saleem *et al.* (2012) reported more thousand seeds weight of sesame for nitrogen at the rate of 90 kg ha^{-1} as compared with 30 and 60 kg ha^{-1}. Rachid (2011) stated that plots treated with crop residues application recorded more seeds spike^{-1} and 1000-seed weight as compared to control plots. Plots supplied sulfur 45 kg ha^{-1} recorded maximum thousand seeds weight and minimum thousand seeds weight (2.10 g) were noted in control plots. The increase in thousand seeds weight might be that sulfur activates the growth and yield component of sesame. Our results were supported by Tahir *et al.* (2014) where sulfur application significantly increased thousand seeds weight and produced heaver thousand seeds with application of 50 kg S ha^{-1}. Sofi *et al.* (2004) also reported that increase in sulfur level up to 40 kg ha^{-1} increased the thousand seeds weight of sesame. Maximum thousand seeds weight with sulfur application (45 and 30 kg ha^{-1}) respectively was also recorded by Vaiyapuri *et al.* (2004).

Mean data related to seed yield (Table 1) showed that crop residues (CR), sulfur (S) and control vs rest was significant, while the interactions between (CR x S) were not significant. In case of crop residue significantly maximum seed yield was recorded for wheat + chickpea residue (4+2 t ha^{-1}) and lowest seed yield was recorded in plots having no crop residue and sulfur. This could be attributed to crop residue which plays a vital role in improving yield related traits which definitely increase the seed yield of sesame. Our results are in line with Paul, (2013), who reported highest seed yield of sesame where 6 t ha^{-1}of millet husks were applied and lowest where 3 t ha^{-1} of groundnut shells where applied. Srisa-ard, (2007) reported that crop residue significantly affect the seed yield of sunflower and highest seed yield was recorded with legume (soybean) residue.

Rahman *et al.* (2013) noted that legume residue had positive influence on both rice yield and N uptake when fertilizer was not used. Kamkar *et al.* (2014) recorded significant difference in seed yield of alfalfa residue treated plots and control plots due to the minimum C:N ratio. Data on effect of sulfur results revealed that maximum seed yield was recorded at the rate of 45 kg ha^{-1} and lowest seed yield was recorded in plots having no sulfur. Maximum grain yield due to sulfur fertilization at the rate of 45 kg ha^{-1} might be due to the fact that sulfur play an important role in improvement of yield related traits i.e branches $plant^{-1}$, capsules $plant^{-1}$, grains $capsule^{-1}$ and 1000 grains weight (shah *et al.,* 2013). The increment in grain yield might be due to the S, which helps in the process of photosynthesis, crop growth rate and net assimilation rate and resulted more seed yield. Sulfur fertilization enhanced the growth and yield parameters as a result increased the grain yield of sesame (Murmu *et al.,* 2015). These findings are supported by the results of Devakumar and Giri (1998) and Tiwari *et al.* (2000), stated more seed yield of sesame due to sulfur fertilization. Maximum grain yield was also recorded by Amudha *et al*. (2005) at 45 kg S ha^{-1}. Similar results were reported by Mondal *et al.* (2012), who stated that sulfur application increased total dry matter and grain yield of oil seed crops. Tahir *et al.* (2014) stated that as S level increased up to 50 kg ha^{-1} the seed yield of sesame was also enhanced.

Data concerning for biological yield of sesame reveals that crop residues and sulfur levels had significantly affected biological yield. In case of crop residue maximum biological yield was recorded for combined application of wheat + chickpea residue (4+2 t ha^{-1}) and lowest biological yield was recorded in control plots. The reason could be that crop residue incorporation improve soil porosity which ensures ample accessibility of oxygen to the plant root that increase nutrients uptake and legume residue provide mineralize nitrogen to principal crop (Motior *et al.,* 2009) which ultimately increase the crop growth and development. Mean value of sulfur levels showed that more biological yield was recorded for sulfur at 45 kg S ha^{-1}, while lower biological yield was noted in control plots. The increase in biological yield of sesame might be due increasing levels of sulfur fertilization which might be linked with increased plant height, more branches $plant^{-1}$ and higher canopy area. Sulfur fertilization play an important role in increasing nutrients uptake and chlorophyll in plants (Tandon, 1991 and Zhang *et al.,* 1999), therefore increase the plant biomass of sesame. Our findings are supported by shah *et al.* (2013), who recorded maximum biological yield of sesame with application of sulfur at 60 kg ha^{-1}.

Data regarding to oil content (%) showed that various crop residues and sulfur significantly affect the oil content (%) while the interaction CR x S was non-significant. Likewise control vs rest was also significant. In case of crop residue more oil content was recorded in plots having combined application of wheat + chickpea residue at the rate of 4+2 t $ha^{-1}$and lower oil content was recorded for control plots. Mean data related to sulfur revealed that sulfur at 45 kg ha^{-1} yield maximum percent oil conteent with respect to plots having no sulfur. The enhancement in percent oil content (%) due sulfur fertilization could be due to its significant role in biosynthesis of oil in plants (Mudd, 1967). This might be due to the effect of sulfur in rapid conversion of nitrogen (crop residue) to crude protein and finally to oil. Our results are in line with Murmur *et al.* (2015), who recorded more percent oil ccontent of sesame seeds by sulfur fertilization. Improvement in oil percent content and oil yield of sesame was also noted by Vaiyapuri *et al.* (2003) due to sulfur fertilization. Shah *et al.* (2013) also stated that more sulfur application significantly enhanced percent oil content and oil yield.

Mean value of the data on oil yield (kg ha^{-1}) showed that the effect of various crop residues and different sulfur levels was highly significant. Similarly control vs rest was also significant, while interaction of CR x S was non-significant. In case of crop residue maximum oil yield was recorded in plots having combined application of wheat + chickpea residue (4+2 t ha^{-1}) and lower oil yield was recorded in control plots. The reason could be that crop residue enhanced oil percentage and seed yield which significantly increase oil yield. In case of sulfur maximum oil yield was observed at 45 kg S ha^{-1}, while lower oil yield was noted in plots having no sulfur. Sulfur fully utilize carbohydrate for the synthesis of oil which might be increased the oil yield (Yadav and Harishankar, 1980). Our findings are supported by the results of Raja *et al.* (2007), who stated that sulfur fertilization at the rate of 60 kg ha^{-1} registered the higher oil yield.

CONCLUSION

It is concluded from the above results that among different crop residues combination application of wheat + chickpea residues (4+2 t ha^{-1}) recorded maximum yield and yield components of sesame which was at par with sole application of chickpea residue at 2 t ha^{-1}. In case of sulfur, fertilization of sulfur at 45 kg ha^{-1} significantly enhanced yield and yield related traits. Therefore, it is recommended that application of sole chickpea residue (2 t ha^{-1}) in combination of sulfur at 45 kg ha^{-1} is recommended to enhanced yield and quality of sesame.

DATA AVAILABILITY

The data that support the findings of this study are listed in the article and are available from the corresponding authors upon reasonable request.

ACKNOWLEDGMENT

This work was supported by HEC (Pakistan) through its NRPU Project No: 10378 for which authors are grateful to HEC Government of Pakistan.

DECLARATION OF INTEREST

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. The authors certified that there is no conflicts of interest associated with this publication, and there has been no significant financial support for publishing this work that could have influenced its outcome. As corresponding Author, I conform that the manuscript has been read and approved for submission by all the named authors.

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Table 1. Treatment structure of the experiment

Treatments	Residues (tons ha-1)	Sulfur (kg ha-1)
T1	Control	0
T2	Sole wheat (4)	15
T3	Sole wheat (4)	30
T4	Sole wheat (4)	45
T5	Sole wheat (4)	60
T6	Sole chickpea (2)	15
T7	Sole chickpea (2)	30
T8	Sole chickpea (2)	45
T9	Sole chickpea (2)	60
T10	Wheat+Chickpea (4+2)	15
T11	Wheat+Chickpea (4+2)	30
T12	Wheat+Chickpea (4+2)	45
T13	Wheat+Chickpea (4+2)	60
T14	Wheat+Chickpea (2+1)	15
T15	Wheat+Chickpea (2+1)	30
T16	Wheat+Chickpea (2+1)	45
T17	Wheat+Chickpea (2+1)	60

Table 2.

Factors	F-values								
	Biological yield		Grain yield				Quality parameters		Net economic return
	Plant height	biological yield	Seeds $capsule^{-1}$	1000-seed weight	Seed yield	Harvest index	Percent oil contents	Oil yield	
Crop residues (CR)	5.51**	2.93*	6.46***	3.71*	12.90***	3.18*	3.07*	16.70***	15.79***
Sulfur (S)	4.88**	3.43*	12.5***	7.84***	17.18***	4.16*	39.8***	54.64***	56.34***
CR x S	0.18^{ns}	0.26^{ns}	0.07^{ns}	0.31^{ns}	0.49^{ns}	0.22^{ns}	0.09^{ns}	0.29^{ns}	0.37^{ns}

Table 3. Effects of crop residues and sulfur on biological components and quality parameters of sesame

Crop Residue (t ha^{-1})	Plant height (cm)	Biological yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha-1)
Sole wheat (4)	170.8 b	3831 b	42.08 b	311 b
Sole chickpea (2)	176.7 a	3913 ab	43.36 a	346 a
Wheat+Chickpea (4+2)	180.5 a	4014 a	43.83 a	359 a
Wheat+Chickpea (2+1)	178.4 a	3887 b	42.64 ab	318 b
LSD (0.05)	5.1	127.2	1.25	16
Sulfur (kg ha^{-1})				
15	171.8 c	3827 b	39.76 c	287 c
30	175.5 bc	3882 b	42.58 b	322 b
45	181.0 a	4023 a	46.54 a	387 a
60	178.1 ab	3912 ab	43.01 b	338 b
LSD (0.05)	5.1	127.2	1.25	16

Table 4. Effects of crop residues and sulfur on economical yield components of sesame

Crop Residue (t ha^{-1})	Seeds capsule^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Harvest index (%)
Sole wheat (4)	53 c	2.89 b	736 b	19.24 b
Sole chickpea (2)	60 ab	3.35 ab	796 a	20.36 a
Wheat+Chickpea (4+2)	62 a	3.74 a	818 a	20.40 a
Wheat+Chickpea (2+1)	56 bc	3.15 b	744 b	19.20 b
LSD (0.05)	4	0.53	31.6	1.06
Sulfur (kg ha-1)				
15	52 c	2.65 c	722 c	18.89 b
30	56 b	3.23 b	757 b	19.53ab
45	65 a	3.93 a	831 a	20.65 a
60	58 b	3.33 b	786 b	20.13 a
LSD (0.05)	4	0.53	31.6	1.06
Interaction				
LSD (0.05)	n's	n's	n's	n's

Table 5.

Crop variables	Control	Rest	Significance
Plant height (cm)	145.2	176.5	***
Seeds capsule^{-1}	42	58	***
Thousand grains weight (g)	2.1	3.3	**
Seed yield (kg ha^{-1})	488	744	***
Harvest index (%)	15.2	19.8	***
Percent oil	38.5	43.0	**
Oil yield	188	334	**
Net return (Rs.)	187783	333582	***

Table 6. Economic assessment of crop residues and sulfur

Crop residue (t ha^{-1})	Inputs cost (Rs.)	Grain value (Rs)	Stover value (Rs)	Total income (Rs)	Net Income (Rs)	VCR
T1	0	97500	32727	130227	130227	
T2	43750	135600	36060	171660	127910	2.92
T3	47500	143600	36471	180071	132571	2.79
T4	51250	162450	38427	200877	149627	2.92
T5	55000	147500	37566	185066	130066	2.36
T6	33750	141100	35008	176108	142358	4.22
T7	37500	155500	37476	192976	155476	4.15
T8	41250	178130	38934	217064	175814	4.26
T9	45000	164100	37065	201165	156165	3.47
T10	73750	158850	38115	196965	123215	1.67
T11	77500	158950	38547	197497	119997	1.55
T12	81250	171550	38655	210205	128955	1.59
T13	85000	165250	38070	203320	118320	1.39
T14	38750	135600	37842	173442	134692	3.48
T15	42500	147250	37515	184765	142265	3.35
T16	46250	160350	38139	198489	152239	3.29
T17	50000	151850	37359	189209	139209	2.78