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Evaluation of Tillage, Nitrogen Fertilizer and Crop Residue Management on some Agronomic Traits of Soybean

Alireza Safahani*[1], Maryamosadat Alavian Petroodi[2], Farshad Ghooshchi[3]

1- Department of Agriculture, Payame Noor University, P.O. BOX: 19395-3697, Tehran, Iran.
2- Department of Agronomy and Plant Breeding, Ghaemshahr Branch, Islamic Azad University, Ghaemshahr, Iran.
3- Department of Agronomy, Varamin Branch, Islamic Azad University, Varamin, Iran.

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ABSTRACT

This study setout to investigate the effect of wheat residue, tillage, and nitrogen fertilizer management on some agronomic traits of soybean as a split split plot based on randomized complete block design with three replications. The main plots included wheat residue management: collecting and leaving residue and sub plot included tillage (without tillage and conventional tillage), and the sub -sub plots included nitrogen fertilizer consumption: base fertilizer, base fertilizer + NF (Nitrogen Factor amount of nitrogen needed for wheat residue degradation to prevent nitrogen deficiency for next crop). The ANOVA results showed that the effect of residue management on harvest index was significant at 5% level. Nitrogen fertilizer significantly affected on grain oil percentage at 5% level and on grain yield and harvest index at 1% level. The highest grain oil percentage, grain yield, and harvest index were obtained in base fertilizer treatment. Moreover, the interactive effect of tillage and residue management on grain yield was significant at 5% probability level. The highest grain yield belonged to residue management and tillage, residue management without tillage, and tillage without residue. Interactive effect of residue and nitrogen fertilizer on number of pod per plant was significant at 1% probability level. Highest number of pod per plant belonged to residue and base fertilizer. Interactive effect of tillage and nitrogen fertilizer on grain oil was significant at 5% level and on the number of pod per plant and grain yield was significant at 1% probability level. Highest oil percentage belonged to the treatment without tillage and base fertilizer, tillage and base fertilizer NF+, with tillage and base fertilizer, and the highest number of pod belonged to tillage and base fertilizer, and highest grain yield belonged to the treatments with tillage and base fertilizer NF+, tillage and base fertilizer, and without tillage and base fertilizer.

Keywords: *Glycin max, Nutrition, Residue, Tillage, Yield.*

***Corresponding Author**: Alireza Safahani * safahani_ali@yahoo.com

INTRODUCTION

Crops residue management is a key element in agricultural production. Farmers have always been concerned about how to deal with crops residue to have the least adverse effect on planting and the yield of next plants (Villarroel *et al*., 2004). Therefore, various methods such as burning crops residue, leaving residues on the soil surface, collecting residue from the farm surface, and plowing residue in soil have been discussed (Salvagiotti *et al*., 2008).

Crop residue management has a remarkable effect on crops yield in a rotation. Failure to select an appropriate method of crops residue management particularly in intensive cropping systems can lead to the incidence of many problems such as soil biological imbalance, change of soil acidity, and decrease of crops yield (Scharf and Wiebold, 2003).

Farhoodi (2004) stated that various crop residue managements such as mixing the residue with soil, removing the residue from the farm, or burning them have a direct relationship with tillage systems. Today, new tillage systems which are called conservation tillage are generally described by saving crop residue on the soil surface of the farm. Moreover, environment protection is the integral part of sustainable development and the foundation of economic development (Schmitt *et al*., 2001).

Anga *et al*. (2006) stated that there is a direct relationship between various crop residue managements, such as mixing the residue with soil and removing the residue from the farm, and tillage systems. Adding organic matter to the soil improves physical, chemical, biological properties and fertility of the soil.

Mayer *et al*. (2003) stated an important factor in crop residue management is the ratio of carbon to nitrogen in organic matter which affects the rate of organic matter decomposition. Mixing wheat residues increased soil organic matter and nutrients such as: Phosphorus, potassium, zinc, and improved root development space and soil fertility. (Salvagiotti *et al*., 2008).

Heenan *et al*. (2004) stated in a research that returning maze residues to the soil compared with removing them from the soil increased the yield of irrigated wheat in rotation with maize although the increase was not significant. Benjamin and Merle (2008) reported time as an important factor in the impact of tillage and crops residue treatment on soil properties and consequently on yield of crops.

Osborne and Riedell (2006) stated that one of the important factors affecting crop residue decomposition is their chemical properties. The suitable soil for farming has 5 to 10% organic matter. The rate of organic matter in soils in Iran is very low and about 1% which is mainly due to natural and accelerated erosion like climatic conditions, lack of use of organic fertilizers, much plowing, wrong sowing, collecting crops residue and burning them and overgrazing, With regard to climatic conditions in Iran, the logical and effective method is to keep soil fertility and to increase soil organic matters in crops residue management and particularly to avoid burning them (Valinejad *et al*., 2013).

The present research can provide necessary data for management of crops residue consumption and soil structure maintenance.

MATERIALS AND METHODS

Field and Treatment Information's

The experiment was carried out in Agricultural Research Center in Baye Kola located in Neka region in Mazandaran province, in North of Iran. The average annual rainfall is 514 mm and the average annual temperature is 16.5°C. The research was conducted as split split plot experiment based randomized complete block design with three replications. The experimental treatments included wheat residue management as the main factor in two levels: collecting and leaving residue, in which, all the available wheat residues were collected and removed from the farm and leaving the residue, all the residues by approximately 7 $t.ha^{-1}$ were left on the soil surface. The sub plots included tillage in two levels: without tillage and conventional tillage, in which some grooves were made on the surface of the soil and the seeds were planted there and tillage operation was done as two perpendicular disks and then some grooves were made on the surface of soil and the seeds were planted. Nitrogen fertilizer as the second subplot included two levels: base fertilizer include 50 $kg.ha^{-1}$ urea base fertilizer + NF (nitrogen factor is in fact the amount of nitrogen needed for wheat residue degradation to prevent nitrogen deficiency for the next crop).

Field Management

To degrade about 7 $t.ha^{-1}$ wheat residues with carbon-nitrogen ratio of 40 (C/N=40), 150 $kg.ha^{-1}$ urea was consumed. The previous cultivation was wheat. After inoculation with rhizobium bacteria, soybean seed (J.K. Var.) (7 $kg.ha^{-1}$) were planted in plots in areas of 9 m^2 in 6 rows. Between row space was 50 cm inter row space was 7 cm. The needed fertilizer were used uniformly according to soil test experimental filed was irrigated by a sprinkler system.

Traits measure

Samples were taken from an area of 3 m^2 of the two middle lines and then economic yield, straw yield, and harvest index were calculated. To measure yield components, 5 plants from each plot were randomly selected. Seed oil was measured by Soxhlet apparatus via AOCS (1997) method to measure the seed protein, total nitrogen was measured through AOCS (1997) method by Kjeltec Auto Analyzer-1030 and then was multiplied by the conversion factor of 5.71. Five plants for growth indices the samples were taken about 27 days after planting in 12 day intervals. Leaf area index was measured using leaf area meter and then it was calculated for an area of 1 m^2. The samples were put in an oven at 70°C for 48 hours to dry and total dry matter and relative growth rate were calculated. In order to determine the rate of root nodulation, five plants in 6 sampling stage were randomly taken out from the depth of 0-30 cm of the soil. After separating the nodes from the root, the samples were placed in the oven for 24 hours (for nodules) and 48 hours (for the roots) at 80°C to dry.

Statistical analysis

The data were analyzed with using SAS software (Ver. 8) and the means were compared using Duncan's multi range test at 5% probability level.

RESULTS AND DISCUSSION

The ANOVA results showed that the effect of tillage and residue management on seed yield was not significant, while the effects of nitrogen fertilizer and the interactive effect of nitrogen fertilizer and tillage on seed yield were significant ($p<0.01$) (Table 1).

Interactive effect of residue management and tillage on seed yield was significant ($p<0.05$) (Table 1). Mean comparison results of nitrogen fertilizer showed that highest seed yield belonged to treatment with application of base fertilizer (4065 $kg.ha^{-1}$) (Fig. 1). Since increase of nitrogen fertilizer increases number of empty pods and decreases number of seed per pod.

Table 1. The ANOVA results of mean squares of effects of crops residue, tillage and nitrogen fertilizer on yield and yield components of soybean

S.O.V	df	Seed yield	Number of pods per plant	Number of seeds per pod	1000-seed weight	Harvest index (%)	Nitrogen harvest index (%)	Seed oil (%)	Seed protein (%)
Replication	2	25067.37^{ns}	55.11^{ns}	0.078ns	165.428^{ns}	49.157^{ns}	1.843^{ns}	0.295^{ns}	1.71^{ns}
Crop residue	1	458713.5^{ns}	119.930^{ns}	0.006ns	1749.334^{ns}	90.909*	17.646^{ns}	0.042^{ns}	3.677^{ns}
Error a	2	151875.37	9.380	0.003	556.966	2.088	4.756^{ns}	0.780	0.609
Tillage	1	525104.167^{ns}	177.290^{ns}	0.01ns	241.3^{ns}	196.024^{ns}	1.545^{ns}	3.227^{ns}	1.931^{ns}
Crop residue × tillage	1	1394908.167*	244.801^{ns}	0.002ns	25.42^{ns}	361.073^{ns}	1.917^{ns}	0.042^{ns}	0.637^{ns}
Error b	4	29164.292	54.839	0.002	47.833	44.882	7.753	0.430	0.783
Nitrogen	1	1178380.167**	7.741^{ns}	0.008ns	2.100^{ns}	237.699**	19.312^{ns}	2.282*	0.176^{ns}
Crop residue × nitrogen	1	104280.167^{ns}	483.394**	0.088ns	160.684^{ns}	15.763^{ns}	0.069^{ns}	1.370^{ns}	0.833^{ns}
Tillage × nitrogen	1	1206913.5**	481.421**	0.005ns	30.6^{ns}	84.788^{ns}	5.561^{ns}	2.042*	0.016^{ns}
Crop residue × tillage × nitrogen	1	158437.5^{ns}	1.378^{ns}	0.051ns	137.76^{ns}	36.828^{ns}	12.285^{ns}	0.540^{ns}	0.052^{ns}
Error c	8	80419.45	22.938	0.021	53.430	19.857	6.227	0.419	0.518
CV (%)	-	7.38	6.35	5.92	3.57	12.46	3.06	2.31	2

**, *: significant at 5% and 1% probability level, respectively, ns: non-significant

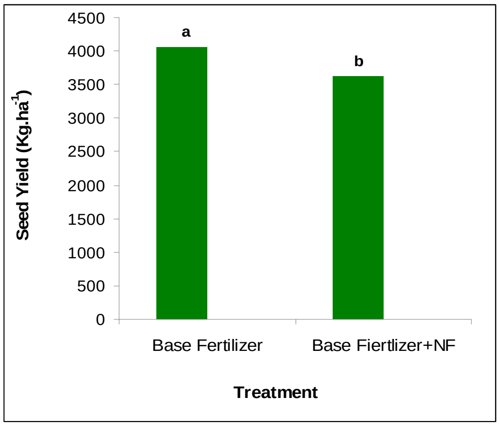

Fig.1. Mean comparison of the effect of nitrogen fertilizer on seed yield via Duncan's method (p<0.05).

So it has a negative effect on seed yield and negative correlation between seed yield and number of empty pods (r= -0.5) (P<0.05) approves of it. Moreover, mean comparison results of the interactive effect of tillage and nitrogen fertilizer showed that the lowest seed yield (3250 kg) belonged to the treatment without tillage and with base fertilizer + NF and the highest seed yield belonged to the treatments without tillage and base fertilizer, with tillage and base fertilizer, and with tillage and base fertilizer + NF and classified in the same level (Fig. 2). Also other researchers found the same result (Caliskan *et al*., 2008, Osborne and Riedell, 2006).

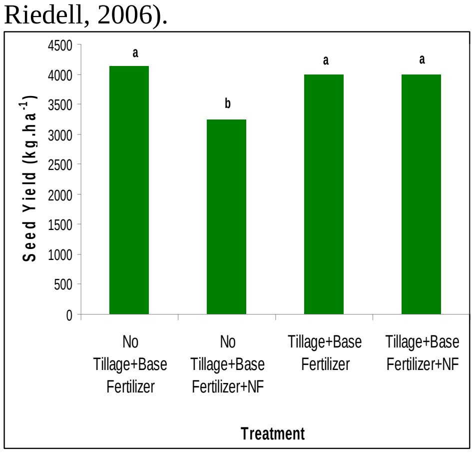

Fig. 2. Mean comparison of the interactive effect of tillage and nitrogen fertilizer on seed yield via Duncan's method (p<0.05).

In addition, the interactive effect of tillage and residue showed that the lowest seed yield belonged to the treatment without residue and without tillage (3316 kg) and the highest one belonged to the treatments without residue and with tillage, with residue and without tillage, and with residue and with tillage, which were classified in the same level (Fig. 3). Valinejad *et al*. (2013) confirmed result.

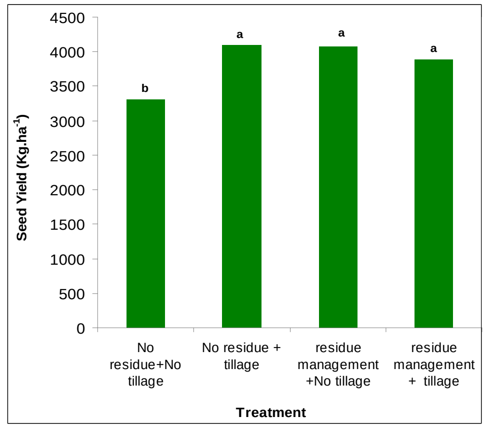

Fig. 3. Mean comparison of the interactive effect of residue management and tillage on seed yield via Duncan's method (p<0.05).

Benjamin and Merle. (2008) reported that time is an important factor impressing the effect of tillage and crops residue management on soil properties and consequently on crops yield. Purcell *et al.* (2002) reported that the system without soil stubble tillage compared with conventional burned stubble tillage had an increasing seed yield, which was similar to the findings of the research. The ANOVA results showed that the interactive effect of nitrogen fertilizer and residue management, tillage and nitrogen fertilizer on number of pod per plant was significant (Table 1), but the effect of residue management, tillage, and nitrogen fertilizer and their interactive effect on number of pod per plant were not significant. Mean comparison results of interactive effect of residue management and nitrogen fertilizer showed the highest number of pod per plant belonged to the residue management and the base fertilizer (82.7) and lowest one belonged to the treatment without residue and base fertilizer (69.3) (Fig. 4).

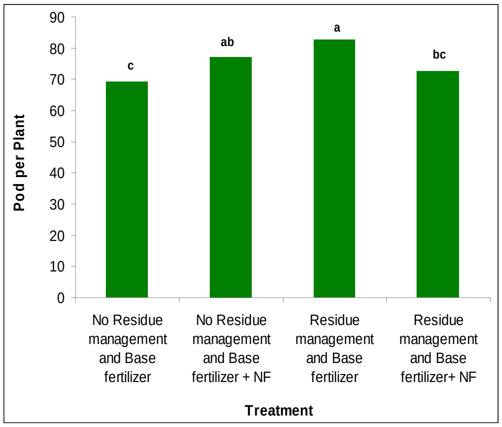

Fig. 4. Mean comparison of the interactive effect of residue management and nitrogen fertilizer on Pod per plant via Duncan's method ($p<0.05$).

Mean comparison results of tillage and the nitrogen fertilizer showed that the highest number of pod per plant belonged to the treatment with the tillage and nitrogen fertilizer (83.2) and so lowest one (68.8) belonged to the treatment without tillage and base fertilizer (Fig. 5).

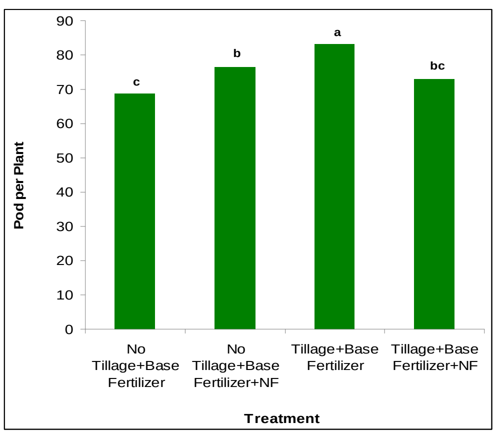

Fig. 5. Mean comparison of the interactive effect of tillage and nitrogen fertilizer on number of pods via Duncan's method ($p<0.05$).

Residues, probably due to the growth promoting substances and the environmental conditions, had a stimulating effect on number of pod per plant (Singleton *et al*., 2002). Tillage provides nitrogen more easily for plant and thus increases number of pod per plant. The ANOVA results showed that the effect of residue management, tillage, nitrogen fertilizer, and their interactive effect on the number of seed per pod and 1000-seed weight was not significant (Table 1). Shah *et al*. (2003) reported that number of seed per pod is mainly controlled by genetic and environmental factors have the least effect on this trait. Abdel-fattah *et al*. (2002) stated that 1000-grian weight is less affected by environmental factors. The effect of residue management and nitrogen fertilizer on harvest index was significant, but effect of tillage and their interactive effect on harvest index were not significant. Mean comparisons showed that the highest percentage of harvest index (37.7%) belonged to the treatment with residue management (Fig. 6), and base nitrogen treatment (38.9%) (Fig. 7).

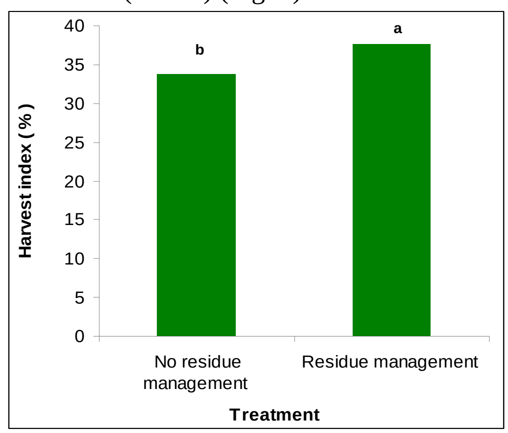

Fig. 6. Mean comparison of the effect of residue management on harvest index via Duncan's method ($p<0.05$).

Leaving the residue and using base fertilizer increased the seed yield and reduced biological yield and consequently increased harvest index. Effect of nitrogen fertilizer and interactive effect of nitrogen fertilizer and tillage on seed oil percentage were significant, but the effect of other treatments and their interactive effect on seed oil percentage were not significant (Table 1).

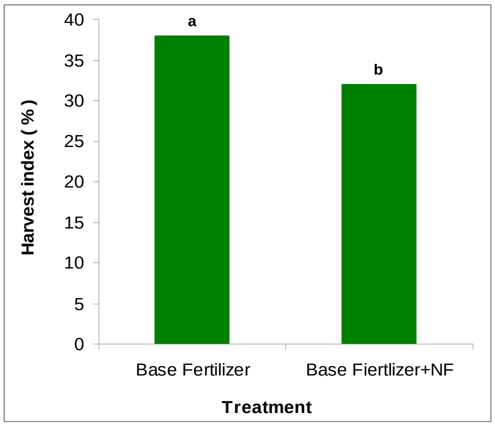

Fig. 7. Mean comparison of the effect of nitrogen fertilizer on harvest index via Duncan's method (p<0.05).

Mean comparison showed that the highest seed oil percentage belonged to base fertilizer treatment (27.675). The results indicate that there is an inverse relationship between oil percentage and nitrogen fertilizer consumption (Fig. 8).

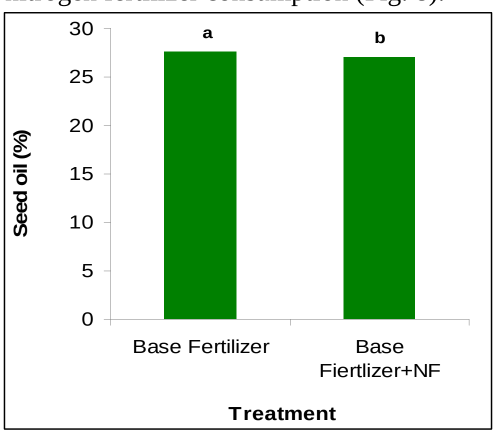

Fig. 8. Mean comparison of the effect of nitrogen fertilizer on grain oil percentage via Duncan's method (p<0.05).

Rathke and Diepenbrok (2005) studied the effect of nitrogen fertilizer on quality of canola seed and concluded that by consumption of the highest dosage of nitrogen the lowest percentage of oil was obtained. The results of interactive effect of tillage and nitrogen fertilizer showed that the lowest oil percentage (26.4%) belonged to the treatment without tillage and base fertilizer + NF, and the highest oil percentage belonged to the treatments without tillage and with base fertilizer, tillage with base fertilizer, and tillage with base fertilizer + NF (Fig. 9).

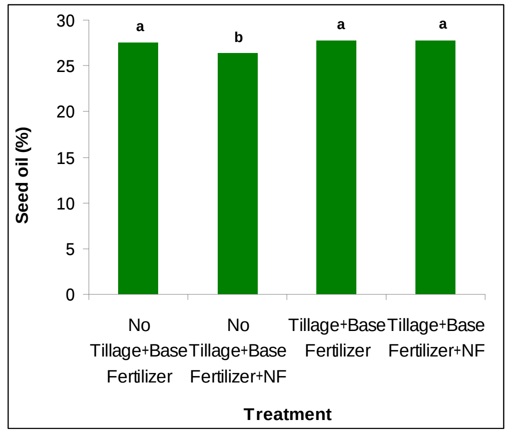

Fig. 9. Mean comparison of the interactive effect of tillage and nitrogen fertilizer on seed oil percentage via Duncan's method (p<0.05).

The effect of residue management, tillage, nitrogen fertilizer and their interactive effect on the harvest index of nitrogen and seed protein were not significant (Table 1). Leaf area index in all treatments had an ascending trend in nearly 80 days after planting and then had a descending trend in the later stages of growth (Fig. 10). Moreover, the highest leaf area index (1.96) in the late growth stages belonged to the treatment with residue and without tillage and with base fertilizer + NF and the lowest one (0.82) belonged to the treatment with residue without tillage and with base fertilizer. Ahmad (2013) stated that early formation of nodules in soybean which depends on nitrogen resulting from symbiotic fixation, compared with plants which use inorganic nitrogen causes delay in the seedling growth and reduces its growth rate. Caliskan *et al*. (2008) stated that application of nitrogen fertilizer had a great effect on leaf development through the increase of leaf width. Dry matter accumulation shows that in all treatments dry matter accumulation has an ascending trend about 100-110 days after planting and then has a descending trend in late stages of growth (Fig. 11).

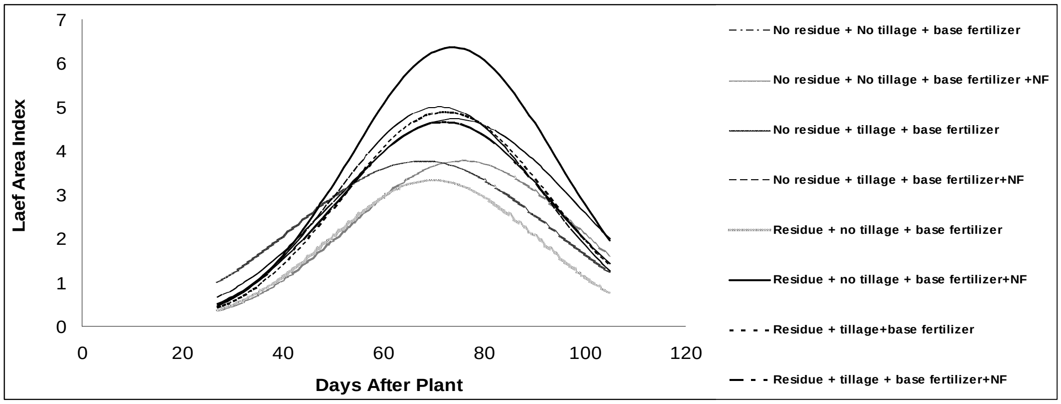

Fig. 10. Leaf area index affected by experimental treatments.

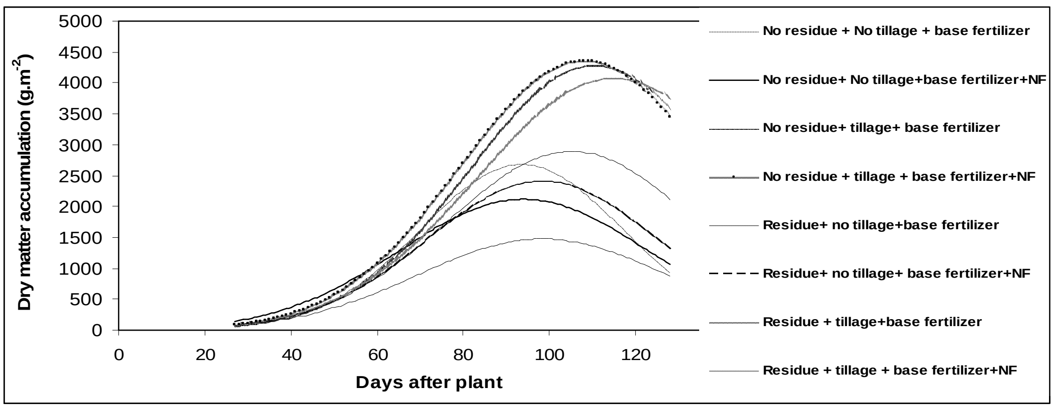

Fig. 11. Dry matter accumulation affected by experimental treatments

Moreover, the highest rate of dry matter accumulation in the late stages of growth belongs to the treatment without residue and with tillage and base fertilizer + NF by 3449.5 g.m^{-2} and the lowest one by 870.18 g.m^{-2} belongs to the treatment with residue and without tillage and with base fertilizer. Dobbelaere *et al*. (2003) stated that dry matter accumulation in plant follows Sigmund curve and includes slow growth, exponential growth, and stable growth phases. Relative growth rate in all treatments has a descending trend over time (Fig. 12). Moreover, in the later stages of growth, the highest relative growth rate belonged to the treatment with residue and tillage and starter fertilizer (0.98) and the lowest one belonged to the treatment with residue and without tillage and with starter fertilizer (0.93).

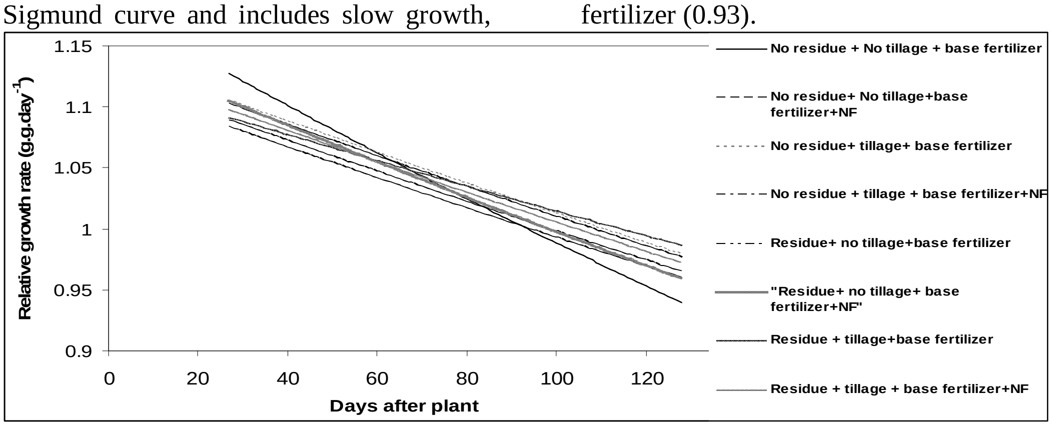

Fig. 12. Relative growth rate affected by experimental treatments.

Tillage and leaving the residue have an effective role in the increase of relative growth rate. Gransee (2001) stated that the highest relative growth rate was achieved in early growth season. Plant height had an ascending trend. Until the mid stages of growth (60 days after planting) this trend had a high speed and at the end of growth stages the rate lowered and in the final stage it remained stable. The highest plant height belonged to the treatment with residue and tillage and base fertilizer + NF (74.44 cm) and the lowest one belonged to the treatment without residue and with tillage and base fertilizer (69.2 cm) (Fig. 13).

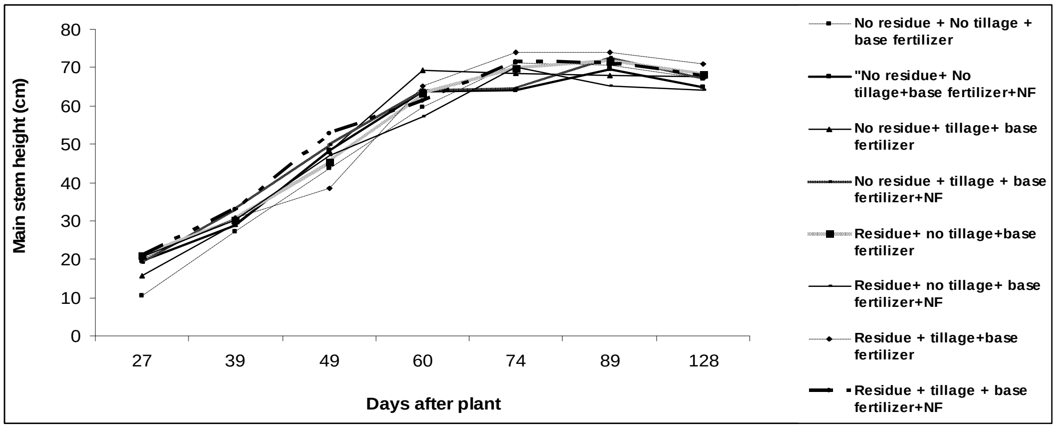

Fig. 13. The interactive effect of residue management, tillage and nitrogen fertilizer on stem height at growth stages.

Borzali *et al.* (2003) stated that, stubble tillage levels compared with non-stubble tillage levels led to the increase of stem height in different soybean varieties. Number of nodes per main stem had an increasing trend at the mid of growth stage (60 days after planting), then until the end of growth stages the number of nodes was almost constant. The highest number of nodes (8.7) belonged to the treatment without residue and without tillage and with base fertilizer + NF (Fig. 14).

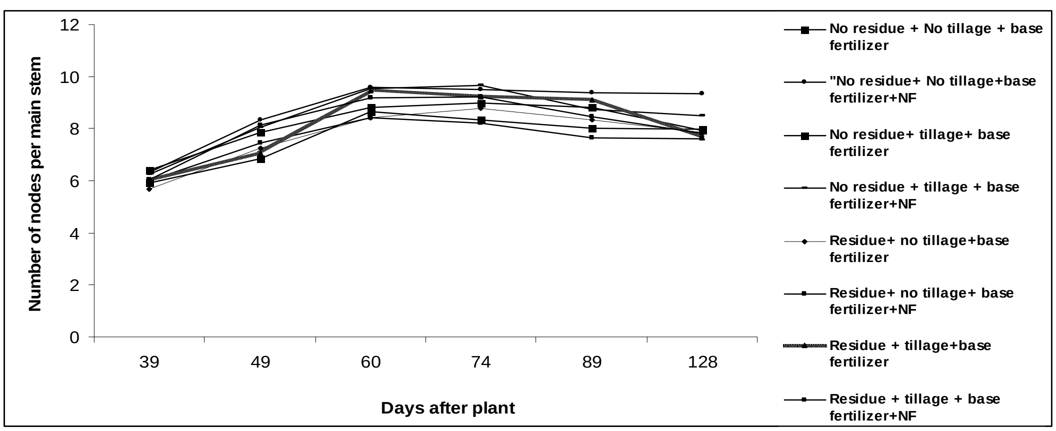

Fig. 14. The interactive effect of residue management, tillage and nitrogen fertilizer on number of nodes per main stem at growth stages.

The number of root nodes in all treatments increased quickly until the middle of growth stage (60 days after planting), and then at the end of growth stage it had a descending trend. The highest number of nodes (40.46) belonged to the treatment without residue and with tillage and base fertilizer (Fig. 15). Moreover, dry weight of root nodes increased gradually until the fourth stage of sampling (60 days after planting), and then in the fifth stage of sampling (74 days after planting) it quickly reached to its peak. In the last stages when bacteria activity had a descending trend, the weight of the formed nodes had a descending trend, as well (Shah *et al*., 2003). The highest dry weight (0.49 g) belonged to the treatment with residue and tillage and the base fertilizer (Fig. 16).

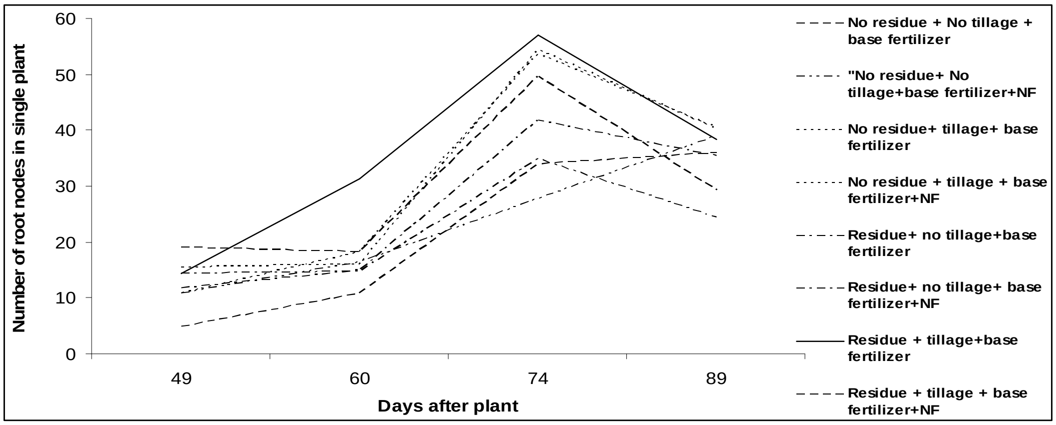

Fig. 15. The interactive effect of residue management, tillage and nitrogen fertilizer on number of root nodes at growth stages.

That result confirmed by some researchers (Borzali *et al*., 2003, Schmitt *et al*., 2001). Goos (2001) stated that the returning straw and stubble into soil, compared with lack of their application, due to the improvement of the soil structural conditions and increase of the soil organic matter, enhanced nodulation process and dry weight of the soybean nodes.

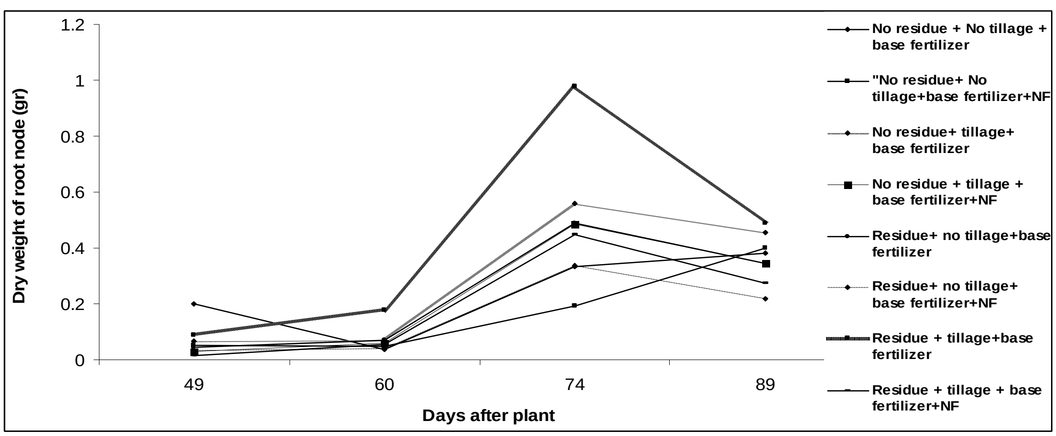

Fig. 16. The interactive effect of residue management, tillage and nitrogen fertilizer on dry weight of root node at growth stages.

CONCLUSION

The results of the research showed that returning crops residue and the use of nitrogen fertilizer not only do not reduce the yield and yield components but also increase the traits. Returning crops residue into the soil, increases the ratio of soil organic carbon to nitrogen. This process reduces soil nitrogen temporarily and if the soil nitrogen is not supplied, it causes the reduction of available nitrogen for plant after the wheat. Moreover, the results of tillage review indicated that the use of the system without tillage had no significant effect on crop yield and yield component. Nitrogen fertilizer as needed solve the problem of slow decomposition of crop residues and reduction of the next crop yield such as soybean. Furthermore, the use of crops residue and non-tillage system maintain soil structure in long time and prevent the environment pollution.

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