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Effects of Nitrogen and Rapeseed Residues on Grain Yield and Yield Components of Sunflower (*Helianthusannuus* L.) and Weed Growth

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ABSTRACT- Crop residue is applied to amend soil properties and increase crop yield. In this study, the effects of rapeseed residues and different rates of nitrogen on grain yield and yield components of sunflower and weed dry matter were investigated. The experiment was conducted at the Experimental Farm of College of Agriculture, Shiraz University, located at Badjgah, Shiraz, Iran in 2007-2008 and 2008-2009 growing seasons. Treatments were nitrogen levels (150, 300 and 450 kgurea ha^{-1}) as main plot and rates of residue rapeseed (25%, 50%, 75%) and without residues included weed free (R0) and weedy check (R1) as sub plot. The experimental design was a split plot based on randomized complete block in four replications. Results showed that the lowest weed biomass, highest grain yield and yield components of sunflower were obtained at 150 and 450 kg N ha^{-1}, respectively. Compared to weedy conditions, the lowest weed biomass (2847.58 kg ha^{-1}) and the highest yield (4087.67 kg ha^{-1}) of sunflower were obtained at 75 and 25 % residue, respectively. Optimum rates of nitrogen fertilizer and rapeseed residue to guarantee maximum grain yield and optimum suppression of weeds were 450 kg $ha^{-1}$and 25%, respectively. Generally, to increase sunflower yield and suppress weeds, it is recommended to integrate cultural practices with use of 450 kg urea ha^{-1} fertilizers and left over 25% of rapeseed residue, was the best treatment.

Keywords: Nitrogen, Residue, Weed, Yield

INTRODUCTION

Reduced crop residue levels generally increase crop yields (1, 27). Balkom et al. (2) showed that leaving residue on the soil surface resulted in higher cotton (*Gossypium*

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herbaceum) yield than when it was incorporated with soil. In the southern parts of Iran such as Fars province where rapeseed is rotated with sunflower, management of rapeseed residue to optimize crop production is crucially important. Since heavy crop residue left on the soil surface after combine harvesting, farmers somehow are forced to reduce the residue levels by burning, harvesting or domestic livestock grazing. If the load of crop residue remaining on the ground is reduced to a certain level, it is possible for the residue to decompose and make nutrients available under the relatively high temperatures accompanied by irrigation (1). Soil incorporation of crop residue improves physical, chemical and biological properties of soil, maintains soil fertility by resolving nutrients, conserving soil water content, and reducing excessive evaporation (12). Growing wheat (*Triticum aestivum* L.) under conservation tillage was also shown to cause lowered soil temperatures Cook et al (4) and increased incidence of certain diseases (15). Phytoxicity of residue of *Brassica* species on Johnson grass has also been evidenced (29). Despite the fact that crop residue can have various potential benefits to crop and soil, a number of research show that these effects can substantially vary. Increased disease incidence or poor seed germination due to heavy crop residue on the ground was shown to cause significant reduction in crop yield (14). Power et al. (20) showed that crop residue can enhance water use efficiency particularly when soil moisture is limiting. It is suggested that crop residue may not significantly contribute to soil carbon (7). Another consequence of leaving residue on the ground is the necessity to apply additional N fertilizer to ensure soil carbon accrual and prevent N immobilization (3).

Sunflower is one of the most widely cultivated oil crop in the world and more than 19979 ha sunflower grown in Fars province. In recent years, the area under cultivation has increased because of its high oil yields (26) and high polyunsaturated fatty acid content and no cholesterol (6).

Researchers showed that sunflower was a crop responsive to nitrogen (N), phosphorus (P) and potassium (K). As sunflower N demand is determined by many environmental and production factors, judicious management of N fertilization is of prime importance. N deficiency reduces vegetative and generative growth and induces premature senescence, thereby potentially lowering yield (11, 13, 17, 28). On the other hand, high N availability may shift the balance between vegetative and reproductive growth toward excessive vegetative development, thus delaying crop maturity and reducing seed yield (5, 8).

Excessive N application may increase the risk of plant diseases and lodging, with a consequent reduction in oil content, and it may also increase ground- and surface-water pollution (9). Barley straw and N rates, generally increase spikes per plant, grains per spikes, 1000-grain weight, grain yield, biological yield and harvest index. Grains per spike and harvest index significantly rise with increase in barley crop residue rate (22). The objective of this experiment was to evaluate the effects of rapeseed residue and N rates on yield and yield components of sunflower and weed biomass.

MATERIALS AND METHODS

Field experiments were carried out in the Experimental Research Farm of the College of Agriculture, Shiraz University(52º 46' E, 29º 50' N) approximately 1810 m above of sea level, Shiraz, Iran in two successive growing seasons 2007-2008 and 2008-2009. The region represents semi-arid climatic conditions with relatively warm summers, cold winters and no rainfall during the growing period. Data on monthly average temperature and rainfall for two years of study and 30-year means of the region as well as some properties of the soil are shown in Tables 1 and 2, respectively.

Table 1. Monthly average temperature and rainfall values during the years of experiment and 30-year means at Agricultural Research Farm (Badjgah), Shiraz. Iran.

	Rainfall (mm)			Temperature(ºC)		
	2007-2008	2008-2009	1975-2005	2007-2008	2008-2009	1975-2005
Jun- Jul	0.00	0.00	0.30	25.80	24.71	23.76
Jul-Aug	0.00	0.00	0.50	24.70	25.91	23.72
Aug-Sep	0.00	0.00	0.40	21.00	22.03	20.40
Sep-Oct	0.00	0.00	1.80	15.70	15.86	15.30
Total	0.00	0.00	3.00	87.2	88.51	83.18

Table 2. Soil properties of experimental sit

Soil depth (cm)	EC (dS m^{-1})	pH	OM (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Soil Texture
0-30	0.664	7.69	1.275	0.15	12.0	520	Silt loam
Soil classification			Fine, mixed, mesic, Cacixerollic Xerochrepts				

The study was a split-plot experiment based on randomized complete block design with four replications. The treatments consisted of N in three levels: 150 (N1), 300 (N2) and 450 (N3) kg urea ha^{-1} as main plot, and residue rates of rapeseed in five levels: 0 percent included weed free (R0) and weedy check (R 1), 25% (equal 750 kg ha^{-1} as R 2), 50% (equal 1500 kg ha^{-1} as R 3) and 75% (equal 2250 kg ha^{-1} as R4) as sub plot. Soil tillage included plowing, twice disking and ridging plots (sized 4 by 3 m). The seeds of sunflower "Eurflour" cultivar were sown in plots by SPD planter (Baldan) on June15th in both years. Rapeseed residues ^{C}/N ratio was 0.795%.

Nitrogen was supplied from urea and added to the plots in two growth stages (½ at planting time and ½ at stem elongation stage). Plots were uniformly irrigated by siphon at planting time. This was based on plant requirement, when no rainfall occurred during growing period (every 7 days). In weed-free conditions, weeds were controlled by Triflouralin (2 liter ha^{-1}) that was applied pre-planting andthenincorporatedintosoil by disking.

Some traits such as grain yield, biomass, plant height, head diameter, seed number per head, mean kernel weight, oil yield (oil percentage grain yield) and harvest index (HI) were measured by randomly selecting seven plants in each plot. The data were analyzed using SAS 9.1, and where analysis of variance showed significant treatment effect, LSD Test was used to compare the means at P<0.05 (23).

RESULTS AND DISCUUSION

The number of seeds per head was significantly affected by the rate of the N application (Table 3). Head diameter was maximum (23. 5cm) when the crop was treated with 450 kg N ha^{-1} (Tables 3 and 4). Similar effects of N fertilizer application on head size of sunflower have also been reported (Massey (16) and Ozer (18).

Table 3. Statistical analysis of effect of nitrogen, rapeseed residues and their interaction on sunflower head diameter, total seed number per head, thousand grain weight and plant height.

Source of Variation	df	HD	TSH	TGW	Ht
Year (Y)	1	136.533333**	340374.008**	346.800000**	1140.833333**
Error (a)	6	2.644444^{n}	3799.764^{ns}	4.866667^{ns}	13.483333**
Nitrogen (N)	2	51.733333**	80828.658**	349.033333**	2055.833333**
Y*N	2	1.633333^{ns}	12803.508**	0.400000^{ns}	115.833333**
Error (b)	12	5.027778*	2047.972^{ns}	7.716667^{ns}	0.033333^{ns}
rapeseed residue (R)	4	482.575000**	337725.429**	318.845833**	1370.550000**
N*R	8	7.462500**	2089.492*	8.939583^{ns}	0.500000^{ns}
Y*R	4	0.700000^{ns}	23549.779**	1.154167^{ns}	0.500000^{ns}
Y*N*R	8	1.925000^{ns}	1607.217^{ns}	0.597917^{ns}	0.500000^{ns}
Error	72	2.525000	2660.326	6.801389	1.47500

df: Degree of freedom, HD: Head diameter, TSH: Total Seed number per head, TGW: Thousand grain weight, H: Plant height
ns: non-significant, * and **: significant at 5 and 1% probability levels, respectively.

Table 4. Effects of nitrogen rates on yield and yield components of sunflower and weeds biomass (mean two years data)

Nitrogen	BY (kg ha^{-1})	GY (kg ha^{-1})	HI (%)	HD (cm)	TGW (g)	TSH	WB (kg ha^{-1})	OY (kg ha^{-1})	H (cm)
N_1	10656.6	3170.20	26.66	21.30	49.70	773.43	178.21	1141.55	157.95
N_2	11876.0	3590.85	28.26	21.90	50.45	812.10	204.82	1273.55	166.45
N_3	12742.2	3662.45	34.42	23.50	22.05	863.05	230.81	1359.05	172.2
LSD 5%)	404.16	115.88	0.16	1.09	1.35	22.05	9.86	1.69	0.09

N_1= 150 kg N ha^{-1}, N_2= 300 kg N ha^{-1}, N_3= 450 kg N ha^{-1}

BY=Biological yield GY=Grain yield, HI=Harvest index, HD=Head diameter, TGW=Thousand grain weight, TSH=Total seed per head, WB=Weed biomass, OY=Oil yield, H=Plant height

The highest seed number per head was produced by 450 kg N ha^{-1} treatment. Results showed that low N fertilizer rate, i.e. 150 kg N ha^{-1}, significantly decreased the number of seeds per head by 10%, as compared with higher levels of nitrogen fertilizer, i.e. 450 kg N ha^{-1} (Table 4). Significant increase in the number of seeds per head with increasing the rate up to 200 kg N ha^{-1} was also reported in other studies (10). The highest 1000- grain weight (55.15 g) was obtained at the rate of 450 kg N ha^{-1} . It has well documented that increasing N rates produced sunflower plants with higher achene weight (8, 15).

Grain yield was also significantly affected by N application (Table 5) and a positive correlation was found between the grain yield and nitrogen level so as the highest yield was obtained by 450 kg N ha^{-1} with an overall grain yield mean of 3.66 t ha^{-1}. Increase in grain yield may be a direct consequence of increase in head diameter, number of seeds per head and 1000-grain weight. Application of N fertilizers was shown to increase sunflower yield (10, 16, 18, 30). Application of N and rapeseed residue significantly ($P \leq 0.01$) affected all estimated sunflo wer characters. Rapeseed residue did not have any significant impact on the biological yield. Interaction between N and rapeseed residue on grain yield and biomass of weeds at all sampling occasions was statistically significant (Table 5).

Table 5. Statistical analysis of effect of nitrogen, rapeseed residues and their interaction on sunflower grain, biological and oil yield, harvest index and weed biomass.

Source of Variation	df	GY	BY	OY	HI	WB
Year (Y)	**1**	**66030.00^{ns}**	**6470413.33****	**294030.00****	**39.90****	**92246.95****
Error (a)	**6**	**58350.98^{ns}**	**687213.26^{ns}**	**211.28^{ns}**	**4.62^{ns}**	**265.24^{ns}**
Nitrogen (N)	**2**	**829220.30****	**3913107.73****	**480270.00****	**670.87****	**27674.18****
Y*N	**2**	**15610.00****	**123213.33^{ns}**	**8490.00****	**53.89****	**2456.35****
Error (b)	**12**	**6574.49^{ns}**	**88158.71^{ns}**	**12.13^{ns}**	**0.10^{ns}**	**409.66^{ns}**
rapeseed residue (R)	**4**	**369165.67****	**804250.97^{ns}**	**172301.05****	**269.13****	**91142.57****
N*R	**8**	**55828.97***	**520700.82^{ns}**	**182.00^{ns}**	**0.08^{ns}**	**5196.03****
Y*R	**4**	**0.001^{ns}**	**0.001^{ns}**	**578.00****	**0.26^{ns}**	**9231.65****
Y*N*R	**8**	**0.003^{ns}**	**0.002^{ns}**	**182.00^{ns}**	**0.07^{ns}**	**2726.43****
Error (c)	**72**	**4995.43**	**858812.50**	**168.14**	**2.60**	**386.86**

df: Degree of freedom, GY: Grain yield, BY: Biological yield, OY: Oil yield, HI: Harvest index, WB: Weed biomass
ns: non-significant, * and **: significant at 5 and 1% probability levels, respectively.

Our findings showed that N application caused a significant change in harvest index. The harvest index increased linearly with the rate of N application and the highest HI was obtained by 450 kg N ha^{-1}. Steer and Hocking (25) reported that harvest index was positively correlated with N supply between floret initiation and anthesis, but not afterwards. A negative correlation has also been reported between harvest index and plant population (24). The highest oil content was obtained by 450 kg N ha^{-1} and the overall mean of oil yield was 1.35 t ha^{-1}. Other researches also reported the positive effect of N fertilization on oil content of sunflower seeds (21, 25). Meanwhile, the lowest weed biomass was obtained at 150 kg N ha^{-1}.

Production potential of sunflower crop is determined by the size of its heads which is the most important yield contributing component. It is approximately a genetically controlled character but also is influenced by environment. Our results showed that application of 25% rapeseed residue significantly increased all estimated characters of sunflower over 50 and 57% levels of rapeseed residue (Table 6). In addition, when retained on the surface, rapeseed residue also decreased weeds density over weedy check. Our results showed that lowest rapeseed residue application (25% residue) with the highest rate of N application (450 kg N ha^{-1}) resulted in maximum plant height (=172.2 cm) and biological yield (12.74 t ha^{-1}), as shown in Tables 5 and 7, respectively .

Table 6. Effects of rapeseed residue on yield and yield components of sunflower and weeds biomass (mean two years data)

Rapeseed residue	BY (kg ha^{-1})	GY (kg ha^{-1})	HI (%)	HD (cm)	TGW (g)	TSH	WB (kg ha^{-1})	OY (kg ha^{-1})	H (cm)
R_0	12219.3	4087.67	34.67	29.29	56.75	980.04	0.00	1363.25	175.33
R_1	11298.8	2847.58	25.60	17.96	48.00	680.08	354.56	1149.83	155.91
R_2	11846.8	3748.42	30.91	23.67	53.21	852.63	261.05	1320.25	170.08
R_3	11839.0	3436.58	29.38	20.96	52.50	845.46	225.94	1241.08	165.16
R_4	11587.2	3252.25	28.35	19.30	48.38	722.75	181.51	1215.83	161.16
LSD (5%)	784.58	157.59	0.93	0.91	1.50	29.68	11.32	7.46	0.69

R_0= Control$_1$ (weed free and non rapeseed residue), R_1= Control$_2$ (weedy check and non rapeseed residue), R_2= 750 kg ha^{-1}, R_3= 1500 kg ha^{-1}, R_4= 2250 kg ha^{-1}

BY=Biological yield GY=Grain yield, HI=Harvest index, HD=Head diameter, TGW=Thousand grain weight, TSH=Total seed per head, WB=Weed biomass, OY=Oil yield, H=Plant height

In addition, there was a linear relationship between the plant height and biological yield with nitrogen rates which might be a consequence of increased vegetative growth caused bynitrogen application. Similar findings were also reported by others (9,15, 25). Maximum plant height (170.08 cm) and biological yield (11.84 t ha^{-1}) were obtained at 25% rapeseed residue which scored higher compared to 50 and 75% levels of rapeseed residue and weedy check (Table 6). Our findings were agreement with those of other reports stating that lower rates of rapeseed residue decreased allopathic effects of residue on vegetative growth markedly (19, 29).

The interaction between N and rapeseed residue showed no significant effect on vegetative growth at all sampling occasions. The results showed that the lowest weed biomass was obtained at 150 kg N ha^{-1} and75% residue (Table 7). Reduced density and vegetative growth of weeds as a result of high rapeseed residue rates might be a possible result of allelopathic effects of rapeseed residue. The interaction between N and rapeseed residue on grain yield was significant ($P \leq 0.05$) (Table 4). Maximum grain yield was recorded 4.4 t ha^{-1} which was obtained at 450 kg N ha^{-1} under weed free condition without application of rapeseed residue (Table 7).

The highest rate of N caused increased vegetative growth, grain yield and yield components of sunflower. Meanwhile when retained on the soil surface, rapeseed residue also resulted in decreased weed density. Hence, it can be concluded that the highest grain yield of sunflower and suppression of weeds can be achieved under agro-climatic conditions such as Fars province when 450 kg urea ha^{-1} and 25% of rapeseed residueis applied.

Table 7. Interaction effects of nitrogen and rapeseed residues on yield and yield components of sunflower and weeds biomass (mean two years data)

Treatments		BY ($kg\ ha^{-1}$)	GY ($kg\ ha^{-1}$)	HI (%)	HD (cm)	TSW (g)	TSH	WB ($kg\ ha^{-1}$)
N_1	R_0	11896.0	3754.0	31.63	27.25	55.25	940.50	0.00
	R_1	10576.5	2358.8	22.43	17.25	46.38	623.25	308.28
	R_2	12441.8	3453.3	27.78	23.00	50.63	790.13	209.03
	R_3	12698.5	3326.8	26.29	20.25	51.00	823.50	224.00
	R_4	11767.0	2958.3	25.19	18.75	45.25	698.75	133.28
N_2	R_0	12398.8	4101.0	33.09	28.13	56.50	973.63	0.00
	R_1	12738.5	3023.0	24.04	17.88	56.50	672.50	341.43
	R_2	13203.3	3899.8	29.56	23.25	46.38	864.75	270.77
	R_3	12567.3	3495.5	27.79	20.88	51.75	829.13	221.64
	R_4	12803.0	3435.0	26.84	19.38	50.00	720.50	190.29
N_3	R_0	11245.8	4408.0	39.29	32.50	58.50	1026.00	0.00
	R_1	11245.8	3161.0	30.34	18.75	51.25	744.50	413.98
	R_2	10581.3	3892.3	35.40	24.75	57.25	903.00	303.37
	R_3	11013.0	3487.5	34.05	21.75	56.50	883.75	232.19
	R_4	10251.3	3363.5	33.01	19.75	52.25	758.00	204.53
LSD (5%)		1796.10	371.50	2.07	2.35	3.65	70.45	27.28

N_1= 150 kg N ha^{-1}, N_2= 300 kg N ha^{-1} , N_3= 450 kg N ha^{-1} , R_0= Control1 (weed free and non rapeseed residue) , R_1= Control2 (weedy check and non rapeseed residue), R_2= 750 kg ha^{-1} , R_3= 1500 kg ha^{-1} , R_4= 2250 kg ha^{-1}

BY=Biological yield GY=Grain yield, HI=Harvest index, HD=Head diameter, TSW=Thousand grain weight, TSH=Total seed per head, WB=Weed biomass

CONCLUSIONS

To guarantee maximum crop yield, effective use of fertilizers customized based on plant and environmental conditions, optimal management of rotated crop residue left on the ground as well as weed control using reduced amount of herbicides are the keys of a better management of agricultural inputs. Although residue management does not lead to complete control of weeds in the field, reduced competitive ability of the weeds as a result of their delayed emergence eventually leads to an increase in crop yield. Generally, to increase sunflower yield and suppress weeds, it is recommended to integrate cultural practices with use of 450 kg urea ha^{-1} fertilizers and left over 25% of rapeseed residue, was the best treatment.

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تاثیر نیتروژن و بقایای کلزا بر زیست‌توده علف‌های هرز، عملکرد دانه و اجزای عملکرد آفتابگردان

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چکیده- بقایای گیاهان زراعی با هدف اصلاح ویژگی های خاک و افزایش عملکرد به کار برده می شود. در این مطالعه تاثیر بقایای کلزا و مقادیر کود نیتروژن بر عملکرد دانه، اجزای عملکرد آفتابگردان و زیست توده علف‌های هرز مورد بررسی قرار گرفت. این آزمایش به صورت یک آزمایش کرت های خردشده بر پایه طرح بلوک های کامل تصادفی با چهار تکرار در مزرعه تحقیقاتی دانشکده کشاورزی دانشگاه شیراز، واقع در منطقه باجگاه در طی فصل های زراعی ۸۷-۱۳۸۶ و ۸۸-۱۳۸۷ انجام گرفت. تیمارها شامل مقادیر نیتروژن (۱۵۰ ، ۳۰۰ و ۴۵۰ کیلوگرم در هکتار به صورت اوره) در کرت های اصلی و مقادیر بقایای کلزا (بدون بقایا شامل بدون علف هرز و شاهد علف هرزی، ۲۵٪، ۵۰٪، و ۷۵٪ به عنوان کرت های فرعی بود. نتایج نشان داد که کمترین زیست توده علف های هرز، بیشترین عملکرد دانه و اجزای عملکرد آفتابگردان به ترتیب از تیمارهای ۱۵۰ و۴۵۰ کیلوگرم نیتروژن در هکتار به دست آمد. در مقایسه با شرایط علف هرزی، کمترین زیست توده علف های هرز ۲۸۴۷/۵۸(کیلوگرم در هکتار) و بیشترین عملکرد آفتابگردان ۴۰۸۷/۶۷(کیلوگرم در هکتار) به ترتیب از تیمارهای ۷۵ و ۲۵ درصد بقایا مشاهده شد. به طور کلی، برای دستیابی به بیشینه عملکرد دانه و سرکوب بهینه علف های هرز، مقدار کاربرد ۴۵۰ کیلوگرم اوره در هکتار و کاربرد ۲۵٪ بقایای کلزا بهترین تیمار بود.
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واژه های کلیدی: بقایا، نیتروژن، علف‌های هرز، عملکرد

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