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Tillage systems and biological nitrogen fixation of soybean (*Glycine max*)

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Introduction Legumes play an important role in rotation systems because of their capability in biological nitrogen fixation (BNF) , but it is not known if N_2-fixation by legumes is affected by different tillage systems . This paper examines N_2 fixation by soybean(*Glycine max*) in no till , stubble retained and conventional cultivation systems on the Loess Plateau , China .

Material and methods This work was conducted in 2002-2003 on a Heilu soil at Qingyang experimental station on the Loess Plateau , Gansu , China . Four tillage treatments were imposed in a random block design with 4 replications . Treatments were : conventional tillage with no stubble retained (t) , conventional tillage but with straw returned to the soil surface after tillage (ts) , no-tillage with no straw (nt) , and no-tillage with stubble retention (nts) . N_2-fixation was assessed using ^{15}N natural abundance with five Soybean and five Prostrate spurge(*Euphorbia humifusa*) (reference plant) samples/plot . The ^{15}N natural abundance were analysed by isotope ratio mass spectrometry and the percent of plant N derived from air (% Ndfa) calculated as :

$$\%\ \text{Ndfa} = 100 \times (\delta^{15}N_{\text{ref . plant}} - \delta^{15}N_{\text{lucerne}}) / (\delta^{15}N_{\text{ref . plant}} - B)$$

Results In 2002 the nitrogen uptake by soybean were all higher than in 2003 under each treatment , but the significant difference neither in annual variation , nor between treatments . There was no evident difference in % Ndfa between any treatments in 2003 (43 .8% ~ 62 .4%) , but it was much higher than in 2002 , and the % Ndfa of soybean was evidently higher in tilled , stubble returned plots (ts) than other treatments . In 2002 the amount of N fixed accounted for 17% ~34 .4% of the totle N uptake by soybean , while in 2003 the quantity of N fixed accounted for 43. 3% ~66. 3% of the N uptake . And the trend of soil NO_3-N (0 ~30cm) at sowing was contrary to the % Ndfa and N fixed in 2002 and 2003 (Table 1) .

Table 1 *Dry matter , dry matter N and N fixed by soybean under different tillage system in 2002 and 2003 .*

Year	Treatment	Dry matter (kg/ha)	Soil NO_3-N (0~30cm) at sowing (kg/ha)	soybean N uptake (kg/ha)	% Ndfa	N fixed by soybean (kg/ha)
2002	t	1299 .0	44 .1	38 .8	17 .6	6 .6
	ts	1172 .3	39 .9	33 .7	34 .3	11 .6
	nt	1129 .6	45 .7	29 .1	22 .3	6 .5
	nts	1179 .8	40 .2	31 .6	19 .2	6 .1
	$LSD_{0.05}$	315 .2	14 .3	11 .4	6 .0	3 .0
2003	t	908 .2	21 .4	24 .7	58 .5	14 .9
	ts	1024 .1	25 .3	26 .4	62 .4	17 .5
	nt	825 .5	23 .8	22 .8	54 .9	12 .9
	nts	936 .7	24 .7	24 .7	43 .8	10 .7
	$LSD_{0.05}$	325 .7	5 .8	9 .6	31 .0	11 .3

Conclusions In the Loess Plateau area , % Ndfa of soybean was increased with a combination of tillage plus straw cover (ts) in 2002 and 2003 . There was a significant negative relationship between the quantity of N fixed by soybean and the amount of NO_3-N in the 0~30cm soil profiles . This research suggests that the soil NO_3-N content of 40kg/ha is the critical value above which plant BNF ability is weakened .