The Journal of Animal & Plant Sciences, 23(1): 2013, Page: 198-200
ISSN: 1018-7081

MUNGBEAN (*Vigna radiata*) YIELD AND DI-NITROGEN FIXATION UNDER MINIMUM TILLAGE AT SEMI ARID POTHWAR, PAKISTAN

S. Ali, A. Hasan, S. S. Ijaz and M. Ansar*

Department of Soil Science & SWC, *Department of Agronomy, PMAS-Arid Agriculture University Rawalpindi-Pakistan
Corresponding author E-mail: shahzadasohail@uaar.edu.pk

ABSTRACT

The field study was carried out during 2005 through 2007 at two locations (Rawalpindi and Fatehjang) in Pothwar, Pakistan to compare minimum tillage with conventional tillage practices for yield performance and nitrogen fixation in mungbean (*Vigna radiata*). The treatments including Minimum Tillage (MT), Conventional Cultivator (CC) and Moldboard Plow (MP) were laid out in a randomized complete block design. All the tillage treatments had equivalent profile moisture content at mungbean sowing. Consequently, the biomass and grain yields were also generally equivalent under all the tillage treatments. The average values were 3.10, 3.19, 3.64 Mg ha^{-1} for biomass and 0.59, 0.58, 0.60 Mg ha^{-1} for grain yield under MT, CC and MP respectively. The results on %Ndfa (nitrogen derived from atmosphere) and total N_2-fixed varied with sites. At Rawalpindi site, though total nitrogen fixation slightly decreased with decrease in tillage intensity, the differences were statistically non significant. The average values were 24, 34, 32 percent for %Ndfa and 15, 19, 21 kg ha^{-1} for total N_2-fixed under MT, CC and MP, respectively. At Fatehjang site, CC had significantly lower nitrogen fixation than MT and MP. The average values were 40, 12, 49 percent for %Ndfa and 24, 6, 32 kg ha^{-1} for total N_2-fixed under MT, CC and MP, respectively. The results of study indicate that comparable mungbean grain yield and nitrogen fixation can be achieved by minimum tillage while avoiding current intensive tillage practices in semi arid Pothwar, Pakistan.

Key words: legume, nitrogen fixation, yield, tillage, dry land.

INTRODUCTION

Since the recent past, there has been enormous emphasis on reducing or completely eliminating tillage for crop production. These practices by definition include systems which leave 30% residue remaining after planting and are termed as conservation tillage systems (Eltiti, 2003). The advantages of conservation tillage include reduced erosion, increased infiltration, yield increase, and carbon sequestration (Brady and Weil, 2002). Different variants of conservation tillage include minimum tillage, reduced tillage, no-till etc. At present about 72 M ha world-over are sown with one form or the other of conservation tillage and the area is increasing every year. Lal, (1997) estimated that the total area under conservation tillage is expected to become 537 M ha by the year 2020. However, tillage is expected to be situation-specific to different agro-ecologies (Samra and Painuly, 2004) and no particular tillage system can be considered universally best. Infact soil types, socio-economic conditions of the farmers, availability of farm machinery, regional concerns and water availability all are unique to different agro-ecological regions.

Although conservation agriculture is not new to Pakistan, the related research efforts have been confined to cereal crops especially rice and wheat grown in irrigated areas. Other crops especially legumes grown in the dryland areas have not received due attention. Besides providing nutritious food grains, legumes play promising role in dryland agriculture through their ability to fix atmospheric nitrogen. The N_2-fixation capacity of legumes is particularly important in developing countries like Pakistan where fertilizer prices are too high for resource poor farmers. Therefore, the current study was carried out to evaluate minimum tillage in comparison with conventional tillage practices on yield performance and nitrogen fixation of mungbean grown in semi arid conditions of Pothwar, Pakistan.

MATERIALS AND METHODS

Locations, climatic conditions and soils: The field research was carried out from summer 2005 until summer 2007, at two locations in the Pothwar plateau, Pakistan. Sites were research farm at PMAS-Arid Agriculture University Rawalpindi (annual average rainfall; 1037 mm) and farmers' field at Fatehjang (annual average rainfall; 862 mm). The rainfall incidence pattern in these areas is of bi-model type with two maxima occurring in late summers and during the winter-spring periods (Figure 1). About 70 % of the total annual rainfall is received during summer rainy season (monsoon rains). The mean maximum temperature during summer ranges from 36 ^oC to 42 ^oC with extremes that are sometimes as high as 48 °C (Nizami *et al*., 2004). As reported by Soil Survey of Pakistan (Govt. of Pakistan, 1974), the soil at Rawalpindi site (33° 38′ N, 73° 05′ E) belongs to Rawalpindi soil series and classified as Typic Ustochrepts; and at Fatehjang site (33° 36′ N, 72° 48′ E) it was Guliana soil series (Typic Ustochrepts). The physical and chemical characteristics of these soils are given in Table 1.

Table 1. Physicochemical characteristics of experimental soils

Soil Character	Mean Values	
	Rawalpindi Site	Fateh Jang Site
Soil texture	Silty clay loam	Silt loam
Saturation (%)	34	35
Soil pH	7.70	7.60
EC (dS m^{-1})	0.25	0.55
Bulk Density(Mg $m^{-3)}$		
0-30 cm depth	1.40	1.27
30-60 cm depth	1.52	1.37
60-90 cm depth	1.60	1.44
Available P (mg kg^{-1})	6.50	4.00
Extractable K (mg kg^{-1})	130	168
Nitrate-N (mg kg^{-1})	3.84	3.00
SOC (Mg C ha^{-1})	6.1	4.5
Taxonomy	Rawalpindi series, Typic Ustochrepts	Guliana series, Typic Ustochrepts

The depth of the soil sampling for variables other than bulk density was 0-30 cm.

Treatments and Sampling: The tillage treatments included i) Minimum tillage (MT) having no tillage before onset of monsoon, ii) Conventional cultivation (CC) at a depth of 15 cm before the onset of monsoon and iii) Moldboard plowing (MP) at depth of 25 cm applied before onset of monsoon. The seed bed preparation for mungbean plantation in all treatment plots was carried out with double pass of conventional cultivator followed by planking. The soil sampling for site characterization from 0-30 cm profile was carried out at the start of experiment (Table1).

Soil moisture content at mungbean plantation was determined to a depth of 90 cm using a soil core. Volumetric water content (VWC) was calculated by multiplying gravimetric water content with bulk density (Brady and Weil, 2002). Shoot biomass and grain yield of mungbean were measured by manual harvest. The samples for nitrogen fixation assessment were collected at pod-fill stage during summer 2007 (see detail below). Rainfall and pan evaporation data were obtained from Regional Agro-met Centers (Figure 1).

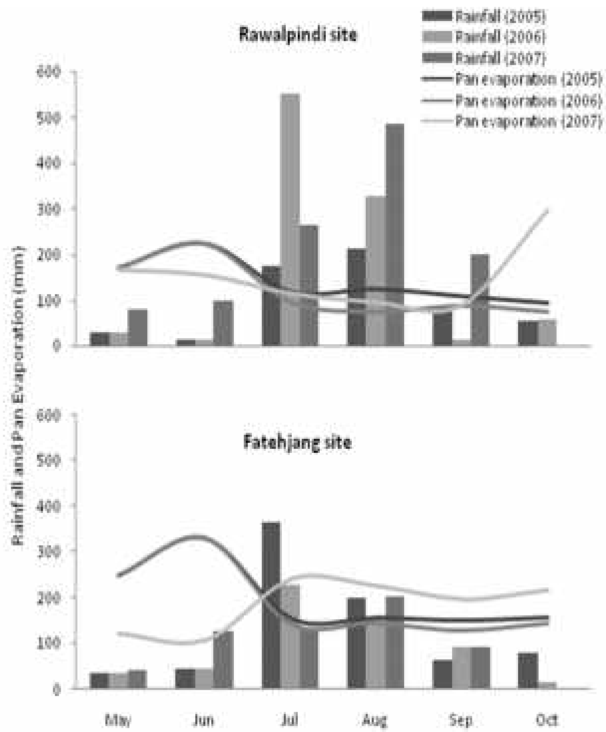

Figure 1: Rainfall (mm) and pan evaporation (mm) data during experimental period

Assessment of N_2-Fixation by Xylem Solute Technique: For nitrogen fixation, xylem sap (vacuum-extracted sap) of mungbean plants was collected by applying a mild vacuum (60-70 kPa) to the base of the cut branch and progressively cutting off small (3-5 cm) stem segments from the top of the branch. The replicate samples were immediately placed on ice and then frozen until analyzed. The shoot clippings from the same plants were collected in a large container during sampling of xylem sap, dried in a forced-draft oven al 80 °C for 48 h. weighed, then ground to pass through one mm sieve. Concentrations of total N (% N) in 300 mg sub-samples of shoots were determined colorimetrically (Anderson and Ingram, 1993).

Concentrations of ureides (allantion and allantoic acid) in xylem sap were measured as the phenylhydrazine derivative of glyoxylate (Young and Conway. 1942). NO_3-N in xylem sap was measured by the salicylic acid method. The amino-N content of sap was determined colorimetrically with ninhydrin (Yemm and Cocking, 1955) using a 1:1, asparagines-glutamine standards. The procedures for uriede, NO_3-N and amino-N were followed as explained by Peoples *et al.* (1989).

The percent relative abundance of ureide-N in xylem sap (%RUN) was calculated by the formula

%RUN = [4 × Ureides / (4 ×Ureides + Nitrate + Amino-N)] × 100

Nitrogen derived from atmosphere (%Ndfa) was calculated at the time of sampling the xylem sap.

%Ndfa = 1.6 (% RUN - 15.9) for plant during pod filling stage. The legume N was derived from the measure of biomass accumulation and tissue N- content.
N kg ha^{-1} = (Legume dry matter kg ha^{-1}) × (%N).

The amount of nitrogen fixed by legume was regulated by two factors, the amount of N accumulated during growth, and the production of that N derived from symbiotic N_2 fixation (%Ndfa)

Amount of N_2 fixed kg ha^{-1} = %Ndfa × crop N kg ha^{-1} × 1.5** 1.5 factor is used to include an estimate for contribution by below ground N (Peoples *et al*., 1989).

Statistical Analysis: The data collected for various characteristics were analyzed by Analysis of Variance in Randomized Complete Block Design. Treatments' means were separated using LSD test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Soil Profile Moisture: The volumetric water content (Table 2) in 90 cm soil profiles at mungbean planting was statistically similar under all tillage treatments. The averages were 21, 20, 21 cm m^{-1} at Rawalpindi site and 19, 19, 20 cm m^{-1} at Fatehjang sites under MT, CC and MP, respectively. The results are in agreement with Gill *et al*. (2000) as well as Chaudhry *et al*. (1990) who also worked in Pothwar, Pakistan and observed that soil water contents did not vary among different tillage systems. Equal moisture capture and storage by different tillage systems have also been reported by Fuentes *et al*. (2003) in Washington State, USA; Latta and O'Leary (2003) in Walpepup, Vic., Australia and Schillinger (2001) in Tribune, Kansas, USA.

Table 2: Volumetric soil water content (cm m^{-1}) at mungbean (*Vigna radiata*) sowing under different tillage treatments

	Volumetric soil water content (cm m^{-1})^{NS†}					
	Rawalpindi site			Fatehjang site		
Treatments /year	2005	2006	2007	2005	2006	2007
MT	17.59	24.12	20.11	16.51	21.03	20.89
CC	16.69	21.93	20.31	15.69	20.55	19.78
MP	18.75	23.67	19.85	17.40	21.9	19.86

† NS; Non significant
Treatments: MT; Minimum tillage, CC; conventional cultivation, MP; moldboard plowing

Shoot Biomass and Grain Yield: The data on shoot biomass (Table 3) and grain yield of mungbean (Table 4) showed generally non-significant differences among tillage treatments. However, as an exception, MT showed lower biomass yield during 2006 at both locations and lower grain yield during 2007 at Fatehjang site. The average values for biomass yield were 3.14, 3.32, 3.49 Mg ha^{-1} at Rawalpindi site and 3.05, 3.05, 3.78 Mg ha^{-1} at Fatehjang site under MT, CC and MP respectively. Similarly average grain yields were 0.66, 0.60, 0.64 Mg ha^{-1} at Rawalpindi site and 0.51, 0.56, 0.55 Mg ha^{-1} at Fatehjang site under MT, CC and MP respectively.

Water is the key limiting factor for crop production in semi arid dryland areas like Pothwar, therefore, generally similar biomass and grain yields under all tillage treatments appears to be a consequent of similar volumetric soil water contents under tillage treatments (Table 2). The results are encouraging in the sense that they indicate possibility of achieving equivalent mungbean yields with much lesser tillage than conventional intensive tillage practices. The tillage intensity at Pothwar is already very high. The farmers plow soils almost 10 times during mere six months of a fallow period. Any decrease in tillage intensity is a considerable saving of input cost. The results are in line with those reported by Bellido *et al*. (2004) and Wani *et al*. (2002) who observed non significant differences among tillage systems for chickpea yield. Comparable yields of different crops under conventional and conservation tillage systems have also been reported by many scientists e.g. Zorita (2000); Baumhardt and Jones (2002), Schlegel *et al*. (1999) and Ijaz and Ali (2007).

Table 3: Effect of different tillage systems on shoot biomass (Mg ha^{-1}) of mungbean

	Shoot biomass (Mg ha^{-1})†					
	Rawalpindi site			Fatehjang site		
Treatments¶/year	2005	2006	2007	2005	2006	2007
MT	4.20^a	1.88^b	3.35^a	3.32^a	0.99^b	4.84^a
CC	4.10^a	2.32^a	3.55^a	3.12^a	1.36^a	4.68^a
MP	3.80^a	2.89^a	3.77^a	3.83^a	1.38^a	6.14^a

† Values with different letters differ significantly ($P<0.05$) in a given year of a site
Treatments: MT; Minimum tillage, CC; conventional cultivator, MP; moldboard plowing

Table 4: Effect of different tillage treatments on grain yield (Mg ha^{-1}) of mungbean

	Grain yield (Mg ha^{-1})†					
	Rawalpindi site			Fatehjang site		
Treatments¶/year	2005	2006	2007	2005	2006	2007
MT	1.24^a	0.56^a	0.18^a	1.14^a	0.30^a	0.09^b
CC	1.10^a	0.53^a	0.18^a	1.21^a	0.33^a	0.18^a
MP	1.15^a	0.62^a	0.16^a	1.15^a	0.32^a	0.19^a

† Values with different letters differ significantly ($P<0.05$) in a given year of a site
Treatments: MT; Minimum tillage, CC; Conventional cultivation, MP; Moldboard plowing

Atmospheric Nitrogen Fixation: The data pertaining to nitrogen derived from atmosphere (%Ndfa) and total nitrogen fixation under different tillage treatments are presented in Figure 2. The tillage effect on %RUN varied with sites. At Rawalpindi site, despite slightly lower %RUN under MT, differences were statistically non significant. At Fatehjang site CC treatment had significantly (av. 69 percent) lower %Ndfa than MT and MP. The values were 24, 34, 32 percent at Rawalpindi site and 40, 12, 49 percent at Fatehjang site under MT, CC and MP treatments, respectively.

The total nitrogen fixation gradually decreased with decrease in tillage intensity at Rawalpindi site *i.e.* MP > CC > MT, though differences were statistically inappreciable. Whereas at Fatehjang site, CC had significantly (av. 79 percent) lesser N_2-fixed than MT and MP treatments. The average amounts of N_2-fixed by mungbean were 15, 19, 21 kg ha^{-1} at Rawalpindi site and 24, 6, 32 kg ha^{-1} at Fatehjang site under MT, CC and MP respectively.

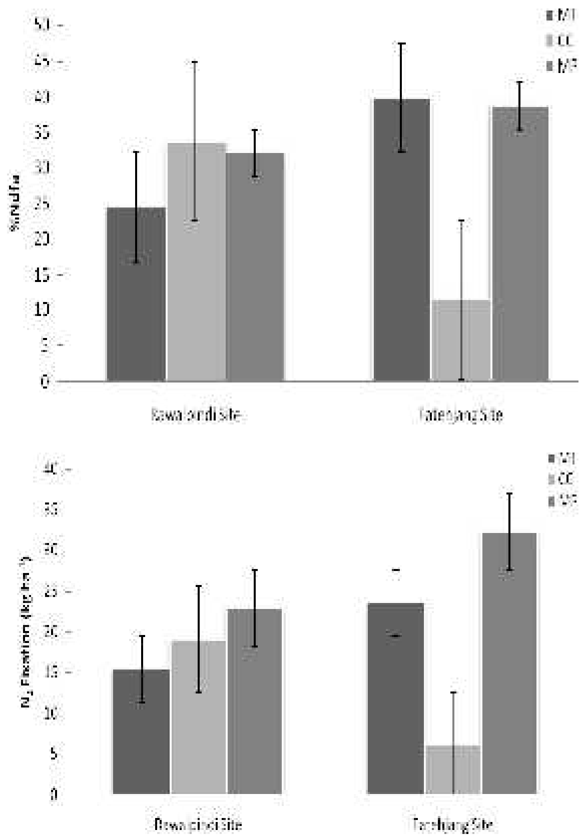

Figure 2: %Ndfa and N_2-fixation (kg ha^{-1}) of mungbean under different tillage treatments

Treatments: MT; Minimum tillage, CC; Conventional Cultivation, MP; Moldboard plowing

At Rawalpindi site, although statistically non significant, %Ndfa as well as N_2-fixation decreased under minimum tillage. On the contrary, at Fatehjang site conventional cultivation had considerably lower %Ndfa and N_2-fixation than minimum tillage as well as moldboard plowing. These results indicate the site specificity of tillage systems as regards their effects on nitrogen fixation. The relatively lesser nitrogen fixation under minimum tillage at Rawalpindi site is similar to observations of Shah *et al*. (2004) who determined the amount of N_2-fixed by soybean in Peshawar Valley and reported that the amount of N_2-fixed by soybean under No-till (a variant of conservation tillage) was substantially lesser than deep tillage. This could have been due to the fact that treatment was recently imposed and beneficial effects of conservation tillage systems especially in terms of reduced bulk density, and increased organic matter content had not sufficient time to develop. Lesser bulk density and increased organic matter content is expected to improve rhizobial activity, root proliferation and nodule formation. The reasons for consistent lower %RUN, %Ndfa and N_2-fixation under conventional cultivation at Fatehjang site are unknown and need further investigations.

Conclusion: The results of the study consistently indicate that comparable mungbean grain yield and atmospheric nitrogen fixation can be achieved under minimum tillage to avoid intensive tillage systems in semi arid Pothwar, Pakistan. However, further multi-location studies are required to observe the long-term effects of conservation tillage systems on nitrogen fixation.

REFERENCES

Anderson, J. M., and J. S. I. Ingram (1993). Tropical Soil Biology and Fertility. A Handbook of Methods. CAB Int, Wallingfold, (UK). 70-87.

Baumhardt, R. L. and O. R. Jones (2002). Residue management and tillage effects on soil water storage and grain yield of dry land wheat and sorghum for a clay loam in Texas. Soil Till. Res. 68:71-82

Bellido, L., R. J Lopez, J. E. Castillo, and F. J. Lopezbellido (2004). Chickpea response to tillage and soil residual nitrogen in a continuous rotation with wheat. J. Crop Sci., 38: 192-200.

Brady, N. C., and R. R. Weil (2002). The Nature and Properties of Soils. 13th ed. Pearson Education, Inc. Delhi, (India).

Chaudhry, M. A., S. Ali, R. Khalid (1990). Effect of mulching on moisture conservation and growth of wheat crop under rainfed condition. *In*: Soil for Agriculture Development, Proceeding of Second National Congress of Soil Science. Faisalabad. Dec., 20-22.

Eltiti, A. E. (2003). Soil Tillage in Agroecosystems. CRC Press, Washington, D.C. (USA). 3-5 pp

Fuentes, J. P., M. Flury, D. R. Huggins and D. F. Bezdicek (2003). Soil water and nitrogen dynamics in dryland cropping systems of Washington State, USA. Soil Till. Res. 71: 33-47.

Gill, S. M., M. S. Akhtar and, Z. Saeed (2000). Soil water use and bulk density as affected by tillage and fertilizer in rainfed wheat production system. Pakistan J. Biol. Sci. 3: 1223-1226

Gomez, K. A. and A. A. Gomez (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons, Inc. (Singapore). PP 680

Govt. of Pakistan (1974). Soil Series Key and Soil Classification. Soil Survey of Pakistan, Ministry of Food and Agriculture. Lahore.

Ijaz, S. S. and S. Ali (2007). Tillage and mulch effects on profile moisture dynamics fallow efficiency and rain fed wheat yield in Pothwar. Pakistan J. Agric. Res. 44: 90-95

Lal, R. (1997). Residue management, conservation tillage and soil restoration for mitigating greenhouse effect by CO_2-enrichment. Soil Till. Res. 43:81-107

Latta, J., G. J. O'Leary (2003). Long-term comparison of rotation and fallow tillage systems of wheat in Australia. Field Crops Res. 83: 173-190

Nizami, M. M. I., M. Shafiq, A. Rashid and M. Aslam (2004). The Soils and Their Agricultural Development Potential in Pothwar. NARC, Islamabad (Pakistan). pp 5-7.

Peoples, M. B., A. W. Fiazah,. B. Rerkasem and D. F. Harridge (1989). Xylem Solute Technique. In: Methods for Evaluating Nitrogen by Nodulated Legumes in the field. Australian Centre for Intl. Agric. Res. Canberra (Australia).

Samra J. S. and D. K. Painuly (2004). No-till options for the rice-wheat cropping system in the Indo-Gangetic plains of India: Some experiences. In: Sustainable Agriculture and the International Rice-Wheat System. Lal, R., P. R. Hobbs, N. Uphoff and D. O. Hansen (eds). Marcel Dekker, Inc. (USA). PP 450

Schillinger, W. F. (2001). Minimum and delayed conservation tillage for wheat-fallow farming. Soil Sci. Soc. Am. J. 65:1203-1209.

Schlegel, A. J., K. C. Dhuyvetter, C. R. Thompson and J. L. Havlin (1999). Agronomic and economic impacts of tillage and rotation on wheat and sorghum. J. Prod. Agric., 12: 4: 629-636

Shah, Z., W. Mohammad, S. M. Shah and M. M. Iqbal (2004). Yields and N_2 fixation of lentil and chickpea as influenced by tillage and P levels under rain-fed conditions. Sarhad J. Agric., 20: 243-249

Wani. S. P., O. P. Rupela and K. K. Lee (1995). Sustainable Agriculture in the Semi-arid Tropics through Biological Nitrogen Fixation in Grain Legumes. International Crops Research Institute for the Semi-Arid Tropics ICRISAT, India., 174: 29-49

Yemm, E. W. and B. F. Cocking (1953). The determination of amino acids with ninhydrin Analysis. 80: 209-213.

Young, E. G. and C. F. Conway (1942). On the estimation of allantion by the riminischryver reaction. J. Biol. Chem. 142: 839-853.

Zorita, M. D. (2000). Effect of deep-tillage and nitrogen fertilization interactions on dryland corn (*Zea mays* L.) productivity. Soil Till. Res. 54: 11-19.