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YIELD AND N-UPTAKE OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIFFERENT FERTILITY LEVELS AND CROP SEQUENCE

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Abstract

The investigations were carried through a series of experiments in two years to confirm the results of two cropping sequences with application of three fertilizer levels. Wheat planted after soybean produced better biological yield (6470.33 kg ha^{-1}), maximum harvest index (42.14%), satisfactory grain yield (2763.33 kg ha^{-1}) and higher N-uptake (119.26 kg ha^{-1}). The increased levels of nitrogen and phosphorus at 150-50 NP kg ha^{-1} respectively increased biological yield (7235.50 kg ha^{-1}), harvest index (44.18%), grain yield (3198.19 kg ha^{-1}) and N-uptake (114.01 kg ha^{-1}). The better yield and soil fertility could be obtained by the inclusion of leguminous crop at least once in a two year cropping sequence, because leguminous crops enrich soil fertility by fixing environmental nitrogen in their root nodules, which in turn supply residual food nutrients to the succeeding crop.

Introduction

A well-planned cropping sequence can reduce insect, pest, disease, ameliorate soil structure, improve organic matter levels, prevent proliferation of weeds and consequently increase the crop yield. The general purpose of rotations is to the improve soil fertility, reduce erosion, weather damage and reduce the reliance on agricultural chemicals and increase net profits (Liebman & Davis, 2000; Bauman *et al.*, 2000). The planned rotation sequence may be of a two or three years or longer period which exhibit the beneficial effects like: improved soil physical, chemical and biological quality; improve water and energy conservation (Cooper, 1999; Rochester *et al*., 2001; Hulugalle & Daniells, 2005).

Generally, the legumes in the rotation increase the available soil nitrogen because legumes are a large, diverse and agriculturally important family in plant kingdom (Heywood, 1971). The benefits of the legumes in cropping systems are well established. Peoples & Craswell (1992); Giller (2001) observed that legumes can fix substantial amount of atmospheric N_2, which allows them to be grown in N-impoverished soils without fertilizer or N inputs. The most important legume species belong to a small group of herbaceous crop and forage species. The main trait common to these legumes, and the trait of most importance to us, is the ability to fix atmospheric nitrogen and convert it to a useable form for plant growth (Allen & Allen, 1981). The fixed nitrogen leads to a higher protein concentration in its various plant parts which in turn enhance diet of human and can also be recycled into the environment as a form of fertilizer. Today, forage legume species have different roles in grassland farming depending on their plant structures and abilities (Heath *et al.,* 1985; Ball *et al.,* 1993).

Due to continuous cropping, and use of above-ground residues for animal feed and fuel, the soil fertility depletes without supplementing organic material (Wani *et al*., 1995 and Giller, 2001). The residues, depending on type and quality, commonly contain 20-80 kg N ha^{-1} and, in some instances, 150 kg N ha^{-1} (Giller, 2001). Now days, the crop rotations have important role for immediate economic benefit in terms of crop yields. For example, sunflower yields over eight years at Crookston, Minnesota were often significantly greater in rotation with other crops than when continuous sunflower was grown (Robinson *et al.,* 1979). The increase in hard red spring wheat yields was achieved when an alternative crop was included in the rotation (Tanaka *et al*., 1998). Thus, the systems that incorporate the cultivation of leguminous crops should be developed for sustainable crop productivity (Sharif *et al.,* 2002; Tarafdar & Claassen, 2003). Crop rotation system, based on periods of bare fallow, was considered to provide a mean of keeping weeds under control. Field trials that compared the yields of spring wheat produced in crop rotations using bare fallow with yields obtained in crop rotations that did not include periods of bare fallow indicated that the practice of using bare fallow appeared to result in lower yields. It is argued that a system of land use involving periods of bare fallow is unsustainable because fallow is a destructive element in land use, contributing to wind, water and biological erosion of soil. There is also significant evidence that bare fallow contributes to the loss of organic matter from soil. Reducing areas of bare fallow has also been found to be economically justified (Sule & Menov, 2004).

Organic matter has a physical function that promotes good soil structure, thereby improving tilth, aeration and moisture movement and retention (Prochazkova *et al.,* 2003 and Ingle *et al.,* 2004), soil fertility, crop productivity, control wind and water erosion, nutrients losses (Maurya & Lal, 1981; Weiser *et al*., 1985 and Bukert *et al*., 2000). Its chemical function is manifested by its ability to interact with metals, metal oxides, hydroxides and clay mineral to form metal organic complexes and act as ion exchange and store house of N, P and S. Soil organic matter has a biological function in that it provides carbon as energy source to N-fixing bacteria, enhances plant growth root initiation facilitating nutrient uptake, improving chlorophyll synthesis and seed germination (Allen & Allen, 1981).

Among the plant nutrients, nitrogen plays a very important role in crop productivity (Ahmad, 1998; Ahmad, 2000) and its deficiency is one of the major yield limiting factor for cereal production (McDonald, 1989 and Shah *et al*., 2003). With continuous cereal cropping systems the N supplied from the decomposition of organic matter must be supplemented from other sources (Strong *et al*., 1986; Herridge & Doyle, 1988; McDonald, 1992). In most developed countries, adequate N is supplied as chemical fertilizer; however, in majority of the developing countries including Pakistan, this is not possible due to high cost of fertilizers, low per capita income and limited credit facilities available to most farmers. As a consequence, farmer either uses the available organic sources or the crop remains un-fertilized (Herridge *et al*., 1995). To satisfy the required level of plant nutrients, farmers in Pakistan are indispensably inclined to use commercial fertilizers. During the last few years, the price of fertilizers in most developing countries, including Pakistan has reached high (Shah *et al*., 1995). This has resulted in a failure to achieve target yields. Considering the beneficial impact of legumes responsible for biological nitrogen fixation on succeeding crops, an experiment was conducted to study the contribution of legumes in the cropping sequences for growth and N-uptake of wheat crop, the results are presented herein.

Materials and Methods

A two years field experiment was conducted on wheat at Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan (25º-40’N, 68º-43’E, altitude 19.5 m asl) on clay loam, non-saline, slightly alkaline (pH= 8.1-8.3), low in organic matter (0.58-0.54%) and poor in available phosphorus (3.00-3.50 mg kg^{-1}).

The experiment was conducted as randomized complete block design (factorial arrangement) with three replications having plot size of 35m^2. The treatments consisted of two cropping sequences [C_1= crop grown before legume and C_2= crop grown after legume (soybean)] and three fertility levels (50-50, 100-50 and 150-50 NP Kg ha^{-1}). Wheat cv TJ-83, was sown before legume (soybean) and after legume crop cultivation. Urea and Di ammonium phosphate (DAP) were used as the source of nitrogen and phosphorus, respectively. All the phosphorus and half of the nitrogen was applied at the time of sowing and the remaining nitrogen was split applied during booting and milky stages. The crop was kept free of weeds. Plant protection measures were adopted when ever necessary.

Determinations: Biological yield (kg ha^{-1})= weight of grain + straw.
Harvest index (%) = Grain yield / biological yield x 100.
N- uptake (kg ha^{-1})= Total dry matter x N plant x 100.
Data were statistically analyzed for each year and combined for 2 years by M STAT C software (M Stat C, 1989). Means were separated by Duncan's Multiple Range Test at $p \leq$ 5%.

Results and Discussion

Biological yield (kg ha^{-1}): The increasing rate of nitrogen significantly increased biological yield in both the years. The higher biological yield (7235.50 kg ha^{-1}) was achieved with the application of 150-50 NP kg ha^{-1}. In different crop sequences, the biological yield was maximum (6470.33 kg ha^{-1}) when wheat planted after legume crop during Year-1 as compared to wheat grown before legume during Year-2 (5774.00 kg ha^{-1}) (Table 1). Biological yield (Kg ha^{-1}) increased with every successive increase in the rate of nitrogen fertilizer. Maximum biological yield was achieved in the treatments where 150 kg nitrogen was applied. Increased rates of nitrogen induced vigorous vegetative growth, which in turn resulted in increased biological yield. Crop sequence with preceding crop as soybean had additional benefit of residual fertility from the proceeding leguminous crop, which when utilized in addition to the applied inorganic nitrogen and resulted exuberant crop growth, which ultimately resulted in increased biological yield. Results are in confirmation with results of Nehra *et al*., (2001) that nitrogen is a nutrient which enhances vegetative growth of the crop and have positive relationship with biological yield.

Harvest index (% age): The application of 150-50 NP kg ha^{-1} produced more harvest index (44.18%). The harvest index was also found more (42.14%) when wheat grown after legume crop as compared to wheat grown before legume (Table 2). There was linear increase in harvest index with each increment in the rate of nitrogen. Minimum harvest index was obtained in the treatments where 50 kg N ha^{-1} was applied, whereas, equally higher harvest index was recorded in the treatment with 100 and 150 kg N ha^{-1}. Nehra *et al*., (2001) have confirmed the results. This behavior can be interpreted in the terms that the lowest level of nitrogen application produced lowest harvest index, but response of harvest index jumped upto the level of 100 kg N ha^{-1}, there after there was no any note worthy increase in harvest index. The response of crop sequences to the harvest index has also been found significant. Maximum harvest index has been achieved in the crop which was grown after the legumes in both the years. This may be due to increased rate of photosynthesis and utilization of assimilates obtained by biological N fixation through succession of legumes as preceding crop which in turn resulted in heavier grains, thereby increased the harvest index.

Table 1. Biological yield (kg ha^{-1}) of wheat as affected by fertilizer levels and crop sequences.

N-P kg ha^{-1}	Years (Y)				
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
50 – 50	4442.00	4860.00	4052.00	4750.00	4526.00
100 – 50	6480.00	7129.00	6340.00	6810.00	6689.80
150 – 50	7350.00	7422.00	6930.00	7240.00	7235.50
Average	6090.67	6470.33	5774.00	6266.67	

C.V= 3.37%

	S.E	LSD1	LSD2
Years (Y)	41.7322	84.7164	113.9289
Sequence	41.7322	847164	113.9289
Nitrogen levels (N)	51.1114	103.7561	139.5341
Y x C x N	102.2227	-	-

Table 2. Harvest index (%) of wheat as affected by fertilizer levels and crop sequences.

N-P kg ha^{-1}	Years (Y)				
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
50 – 50	35.00	38.00	34.30	37.50	36.20
100 – 50	43.50	43.60	43.40	43.50	43.50
150 – 50	43.70	44.83	43.40	44.80	44.18
Average	40.73	42.14	40.37	41.93	--

C.V= 4.99%

	S.E	LSD1	LSD2
Years (Y)	0.4203	0.8532	1.1474
Sequence	0.4203	-	-
Nitrogen levels (N)	0.5147	1.0448	1.4051
Y x C x N	1.0294	-	-

Grain yield (kg ha^{-1}): The application of nitrogen linearly increased the grain yield of wheat crop and maximum response (3198.19 kg ha^{-1}) was exhibited with incorporation of 150-50 NP kg ha^{-1}. Among the crop sequences, higher grain yield (2763.33 kg ha^{-1}) was obtained when the wheat planted after legume crop whereas, wheat sown before legume recorded minimum grain yield (1390.00 kg ha^{-1}) (Table 3). The maximum grain yield kg ha^{-1} was produced from the plots, where 150 kg N ha^{-1} was applied. Results are supported by Hussain & Shah (2002) who also were in the view that N significantly increased grain yield of wheat. Results are in accordance with Bazitov (2000) and Bhagat *et al*., (2001) that more number of tillers plant^{-1}, longer spikes, more number of spikelets spike^{-1} and greater number of fertile florets resulted in maximum number of grain filled thus, all collectively resulted into increased grains yields ha^{-1}. The results further showed significant effect of crop sequences for the grain yield. Higher grain yields were achieved in both the years in the

Table 3. Grain yield (kg ha^{-1}) of wheat as affected by fertilizer levels and crop sequences.

N-P kg ha^{-1}	Years (Y)				
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
50 – 50	1554.00	1850.00	1390.00	1780.00	1643.50
100 – 50	2821.00	3110.00	2750.00	2960.00	2910.25
150 – 50	3208.75	3330.00	3010.00	3244.00	3198.19
Average	2527.92	2763.33	2383.33	2661.33	--

C.V= 8.04%

	S.E	LSD1	LSD2
Years (Y)	42.3923	86.0563	115.7309
Sequence	42.3923	86.0563	115.7309
Nitrogen levels (N)	51.9198	105.5972	141.7411
Y x C x N	103.8395	210.7942	283.4818

Table 4. N-uptake (kg ha^{-1}) in wheat plant as affected by fertilizer levels and crop sequences.

N-P kg ha^{-1}	Years (Y)				
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
50 – 50	51.08	97.78	53.16	77.52	69.88
100 – 50	10.95	131.17	100.42	108.96	111.56
150 – 50	115.24	120.84	106.44	113.52	114.01
Average	90.69	119.26	86.67	100.00	---

C.V= 8.04%

	S.E	LSD1	LSD2
Years (Y)	42.3923	86.0563	115.7309
Sequence	42.3923	86.0563	115.7309
Nitrogen levels (N)	51.9198	105.5972	141.7411
Y x C x N	103.8395	210.7942	283.4818

crop sequences which included leguminous (soybean) as preceding crop. This may also be due to the process of symbiosis in legumes where mutual contact between rhizobium bacteria and the leguminous crop occur and roots fix atmospheric nitrogen in the nodules which supply nitrogen to the succeeding crop. The results are in accordance with the results obtained by Ghosh *et al*., (2000); Pencher & Gramatikov (2002) and Rusu *et al*., (2001) that legume growing in the crop sequence produce sufficient nitrogen and reduce the rate of in-organic nitrogen.

N-uptake: The increasing rate of nitrogen also increased N uptake in both the years. The application of 150-50 NP kg ha^{-1} resulted higher N uptake (114.01 kg ha^{-1}). In different crop sequences the N uptake was maximum (119.26 kg ha^{-1}) when wheat was planted after legume during year-1. It is clearly evident from the data that N uptake increased due to previous legume crop. It was further observed that as the N levels increased from 50 to 150 kg ha^{-1}, the N uptake also increased from 69.88 to 114. 01 kg ha^{-1} (Table 4). As per statement of Kubat *et al*., (2003) that both the organic and mineral fertilization enhanced significantly the N-uptake by the cultivated crops. The effect of nitrogen input was the highest with the alternate cropping indicating that it was more demanding for the external N-input. They further reported that with continuous planting the soil structure degraded. Rawat & Pareek (2003) also supported the finding of the study by concluding that the N uptake of the crop also increased with increasing rates of N.

Conclusions

The overall results of the present investigations conclude that nitrogen fertilizer is essential nutrient for achieving satisfactory crop yields. The increased soil productivity and fertility for crop production could be obtained by the inclusion of leguminous crop at least once in a two year cropping sequence, because leguminous crops enrich soil fertility by fixing environmental nitrogen in their root nodules, which in turn supply residual food nutrients to the succeeding crop.

References

Ahmad, N. 1998. Plant nutrition management for sustainable agricultural growth in Pakistan. *Proceedings of Plant Nutrition Management for Sustainable Agricultural Growth* (December 8–10, 1997), National Fertilizer Development Centre, Planning and Development Division, Government of Pakistan, Islamabad, pp. 11-24.

Ahmad, N. 2000 Fertilizer scenario in Pakistan policies and development. *Proceedings of Conference Agricultural and Fertilizer Use*. 2010 NFDC, P and D Division, Government of Pakistan, February 15-16.

Allen, O.N. and E.K. Allen. 1981. The leguminosae: A source book of characteristics, uses, and nodulation. Univ. of Wisconsin Press, Madison, USA.

Ball, D.M., C.S. Hoveland and G. D. Lacefield. 1993. Southern forages. Potash & Phosphate Inst. Atlanta, pp. 122-130.

Bauman, D.T., M.J. Kroff and L. Bastiaans. 2000. Inter cropping leeks to suppress weeds. *Weed Research*, 40: 359-374.

Bazitov, V. 2000. Production potential of wheat under different systems of soil tillage and fertilization. *Rasteniev"dni Nauki*, 37(10): 888-891.

Bhagat, R.K., R.P. Singh, B.M. Choudhary and R.K. Singh. 2001. Profitability of late sown wheat under small production system. *Journal of Research, Birsa Agricultural University*, 13(2): 141-143.

Blaser, R.E., D.D. Wolf and H.T. Bryant. 1973. Systems of grazing management. pp. 581-595. In: *Forages, the science of grassland agriculture*. (Eds.): M.E. Heath, R.F. Barnes and D.S. Metcalfe. 3rd. ed. Iowa State Univ. Press, Ames.

Bukert, A., A. Bationo and K. Possa. 2000. Mechanism of residue Mulch-induced cereal growth increases in West Africa. *Soil Sci. Soc. Am. J*., 64:1-42.

Cooper, J.L. 1999. A grower survey of rotations used in the New South Wales cotton industry, *Aust. J. Exp. Agric*., 39: 743-755.

Ghosh, B.N., Ved Prakash and R.D. Singh. 2000. Phosphorus removal and P balance in soybean-wheat cropping sequence under long-term fertilizer experiment. *Journal of Inter Academicia*, 4(2): 260-263.

Giller, K.E. 2001. Nitrogen fixation in tropical cropping systems. CAB International, Wallingford, UK, pp. 423.

Heath, M.E., R.F. Barnes and D.S. Metcalfe. 1985. Forages, the science of grassland agriculture. 4th ed. pp. 431-437, Iowa State Univ. Press, Ames.

Herridge, D.F. and A.D. Doyle. 1988. The narrow leafed lupin (*Lupinus angustifolius* L.) as a nitrogen fixing rotation crop for cereal production. 2: Estimates of fixation by field grown crops. *Aust. J. Agric. Res*., 39: 1017-1028.

Herridge, D.F., H. Marcellos, W. Felton, G. Schwenke, M. Aslam, S. Ali, Z. Shah, S.H. Shah, S. Maskey, S. Bhuttari, M.B. Peoples and G. Turner. 1995. Management of legume N_2 fixation in cereal system. Proceedings of IAEA/FAO International Symposium On Nuc. and Related Tech. in Soil/Plant Studies on Sustainable Agriculture and Environmental Preservation. 1994 Vienna, Austria, pp. 237-250.

Heywood, V.H. 1971. The leguminosae: A systematic purview. Pp.1-29. In: *Chemotaxonomy of the Leguminosae*. (Eds.): J.B. Harborne, D. Boulter and B.L. Turner. Academic Press, London.

Hulugalle, N.R. and I.G. Daniells. 2005. Permanent beds in Australian cotton production systems. *Australian Journal of Soil Research*, 39(2): 317-328.

Hussain, M.I. and S.H. Shah. 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of N, P and K. *International Journal of Agriculture and Biology*, 4(3): 362-364.

Ingle, S.N., S.V. Malode, R.M. Ghodpage and S.D. Jadhav. 2004. Effect of long-term use of vegetative barriers and FYM on yield and soil fertility under cotton-sorghum rotation in vertisol. *Annals of Plant Physiology*, 18(1): 42-44.

Kubat, J., J. Klir and D. Pova. 2003. The dry matter yields, nitrogen uptake, and the efficacy of nitrogen. *Plant Soil & Environment*, 49(8): 337-345.

Liebman, M. and A.S. Davis. 2000. Integration of soil, crop and weed management in low-external-input farming systems. *Weed Research*, 40: 27-47.

Maurya, P.R. and R. Lal. 1981. Effects of different mulch materials on soil properties and on root growth and yield of maize (*Zea mays*) and cow pea (*Vigna uniguiculata*). *Field Crop Res*., 4: 33-45.

McDonald, G.K. 1989. The contribution of nitrogen fertilizer to the nitrogen nutrition of rainfed wheat (*Triticum aestivum*) crops in Australia. *Aust. J. Exp. Agric*., 29: 455-481.

McDonald, G.K. 1992. Effects of nitrogenous fertilizer on the growth, grain yield and grain protein concentration of wheat, *Aust. J. Agric. Res*., 43: 949-967.

MStat, C., R.D. Freed and S.P. Eisensmith. 1989. Mstatc Statistical Package. Crop and Soil Department, University Extension Services, University of Michigan, East Lansing, Michigan, USA.

Nehra, A.S., I.S. Hooda and K.P. Singh. 2001. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum*). *Indian Journal of Agronomy*, 46(1): 112-117.

Pencher, P.N. and B. Gramatikov. 2000. Influence of some agro-technical factors on the productivity of wheat cultivar Miryana. *Rasteniev"dni Nauki*, 37(10): 899-902.

Peoples, M.B. and E.T. Craswell. 1992. Biological nitrogen fixation: investments, expectations and actual contributions to agriculture. *Plant Soil*, 144: 13-39.

Prochazkova, G., J. Hruby, J. Dovrtel and O. Dostal. 2003. Effects of different organic amendment on winter wheat yields under long-term continuous cropping. *Plant Soil & Environment*, 49(10): 433-438.

Rawat, S.S. and R.G. Pareek. 2003. Effect of FYM and NPK on yield and nutrient uptake for soil fertility in wheat. *Annals of Agri. Bio. Research*, 8(1): 17-19.

Robinson, R., J., Smith and J.V. Wiersma. 1979. Sunflower monoculture and crop rotation. Misc. Report 166 Ag. Exp. Sta., University of Minnesota, USA.

Rochester, I.J., M.B. Peoples, N.R. Hulugalle, R.R. Gault and G.A. Constable. 2001. Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. *Field Crops Research*, 70(1): 27-41.

Rusu, C., D. Dornescu, E. Istrati and R. Rusu. 2001. Effect of long-term fertilization on wheat yield on the typical chernozem and dark luvisol of the Moldavian plateau. *Cercetari Agronomice in*

Moldova, 34(3/4): 29-37.

Shah, Z., S.H. Shah, D.F. Herriedge, M.B. Peoples, M. Aslam, S. Ali and M.T. Tariq. 1995. Pakistan's agriculture-cereal and legume production. *J. Agric. Univ. Wales Aberyswyth U.K*., 75: 89-98.

Shah, Z.H., S.H. Shah, M.B. Peoples, G.D. Schwenke and D.F. Herriedge. 2003. Crop residue and fertilizer N effects on nitrogen fixation and yields of legume–cereal rotations and soil organic fertility. *Field Crops Res*., 83: 1-11.

Sharif, M., R.A. Khattak and M.S. Sarir. 2002. Wheat yield and nutrients accumulation as affected by humic acid and chemical fertilizers. *Sarhad Journal of Agriculture*, 18(3): 323-329.

Strong, W.M., J. Harbison, R.G.H. Nielsen, B.D. Hall and E.K. Best. 1986. Nitrogen availability in a Darling Downs soil following cereal, oilseed and grain legume crops. 2: Soil nitrogen accumulation. *Aust. J. Exp. Agric*., 26: 347-351.

Sule and M.K. Menov. 2004. The theory and practice of crop rotation in Northern Kazakhstan. *Mezhdunarodny Sel'skokhozya stvenny Zhurnal*, 4: 54-56.

Tanaka, D.L., S.D. Ries, S.D. Merrill and A.D. Halvorson. 1998. Alternative crops for rotations. In: *Manitoba-North Dakota Zero-Tillers Proceedings*, pp. 115-122.

Tarafdar, J.C. and N. Claassen. 2003. Organic phosphorus utilization by wheat plants under sterile conditions. *Biology & Fertility of Soils*, 39(1): 25-29.

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. *Plant Soil*, 174: 29-49.

Weiser, G.C., K.F. Grafton and D.L. Borehole. 1985. Nodulation of dry beans by commercial and indigenous strains of Rhizobium facial. *Agron. J*., 77: 856-858.

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