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IMPACT OF DIFFERENT NITROGEN LEVELS ON COTTON GROWTH, YIELD AND N-UPTAKE PLANTED IN LEGUME ROTATION

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Abstract

A series of experiments were conducted at Sindh Agriculture University, Tandojam. The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement consisting four replications and repeated in the 2nd year. The treatments consisted crop two sequences [(C_1= Cotton (before legume) and C_2= Cotton (after legume)] and varying fertility levels (F_1=150-50, F_2=100-50 and F_3=150-50 NP Kg ha^{-1}). The berseem was cultivated as leguminous crop in the sequence. The crop sequences revealed that the cotton crop sown after legume produced tall plants (99.41 cm), higher production of monopodia $plant^{-1}$ (2.68), sympodia $plant^{-1}$ (14.10), more bolls $plant^{-1}$ (24.83), heavier seed index (6.83 g), maximum GOT (34.47%), better staple length (28.83mm), higher oil content (22.87%), superior seed cotton yield (2428 kg ha^{-1}) and N-uptake increased upto 91.17 kg ha^{-1}. The incorporation of NP fertilizer significantly affected crop parameters. Among the tested fertilizers, 150-50 NP kg ha^{-1} recorded maximum plant height (102.63 cm), monopodia $plant^{-1}$ (2.61), sympodia $plant^{-1}$ (13.70), bolls $plant^{-1}$ (26.40), seed index (6.83g), GOT (34.57%), staple length (28.65mm), oil content (23.10%), seed cotton yield (2538.25 kg ha^{-1}) and N-uptake (113.43 kg ha^{-1}). It is concluded that nitrogen and phosphorus fertilizers are essential nutrients, but for maintenance of soil fertility and enhancement of crop productivity the inclusion of leguminous crop at least once in a two year cropping sequence is necessary, 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. Thus, (i) continuous cropping in the sequence of wheat-cotton be avoided, (ii) the higher yields of cotton and wheat could be achieved in the farming system which includes legumes in crop rotation, (iii) the application of 150-50 NP kg ha^{-1} is sufficient for satisfactory yield and qualitative characters of cotton and (iv) the use of in-organic nitrogenous fertilizers could be minimized by succession of legume crop in the crop sequence.

Introduction

The crop rotation improve or maintain soil fertility, reduce erosion, reduce the risk of weather damage, reduce 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; improved energy conservation and timeliness of land preparation; and better water conservation (Cooper, 1999; Rochester *et al*., 2001; Hulugalle & Daniells, 2005). The research reports indicate that the 3-year cotton-corn soybean rotation with a legume and with 134 kg N ha^{-1} $year^{-1}$ had higher amounts of soil organic matter, soil microbial biomass C and crop yield, but cotton grown every year without a legume or N fertilizer had a lower amount of soil organic matter, soil microbial biomass C and N and cotton seed yield than all other rotations (Entry *et al*., 1996). Giller (2001) observed that legumes can fix substantial amounts of atmospheric N_2, which allows them to be grown in N-impoverished soils without fertilizer or N inputs. The fixed nitrogen leads to a higher protein concentration in its various plant parts which in turn enhances our diet and can also be recycled into the environment as a form of fertilizer. Despite these advantages, farmers prefer to remove crop residues off the field to feed livestock or use them as fuel or as building materials. To keep the soil productive and sustainable one has to continuously replenish soil organic matter through including legumes in crop rotations and retaining crop residues. With much of the cropping in less developed countries, the above-ground residues are removed with the grain to be used as animal feed or fuel (Wani *et al*., 1995; 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). One immediate economic benefit of crop rotations is improved yields (Robinson *et al.,* 1979). Thus, the systems that incorporate the cultivation of leguminous should be developed for sustainable crop productivity (Sharif *et al.,* 2002; Tarafdar & Claassen, 2003). Organic matter obtained from legumes has: (i) physical function which promotes good soil structure, there by improving tilth, aeration and moisture movement and retention (Prochazkova *et al.,* 2003; Ingle *et al.,* 2004), (ii) 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 and (iii) 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). Research studies have shown that regular and proper addition of organic materials (crop residues) are very important for maintaining the tilth, fertility and productivity of agriculture and controlling wind and water erosion more than 50 % and preventing nutrients losses by run-off and leaching (Bukert *et al*., 2000). The expected reduction in soil erosion would be even greater on steeper slopes (Paterson, 2003).

Among the plant nutrients, nitrogen play a very important role in crop productivity is an important determinant of the growth and yield of irrigated cotton (Ahmad, 2000). Applications of fertilizer N of between 100 and 215 kg N ha^{-1} are typically required to optimize lint yield of irrigated cotton in Australia (Constable & Rochester, 1988), USA (McConnell *et al*., 1995), China (Jin *et al*., 1997) and Egypt (Hussein *et al*., 1985). Thus, the N-deficiency is one of the major yield limiting factors for cereal production (Shah *et al*., 2003).

In the past, wheat (*Triticum aestivum*) has been the dominant rotation crop, but recently, there has been a trend for cotton growers to include legumes in their cropping systems, in the belief that residual fixed N may replace some N fertilizer required by following cotton crops. Data collected from commercial dryland and irrigated legume crops indicate 95–270 kg fixed N ha^{-1} can remain in vegetative residues after grain harvest (Peoples *et al*., 1995; Schwenke *et al*., 1998; Rochester *et al*., 2001). Substantial savings in fertilizer N have been demonstrated when maize (*Zea mays*) follows legumes (Oyer & Touchton, 1990; Omay *et al*., 1998). In Australia, Hearn (1986) found that a legume crop grown prior to cotton could enhance lint yield. Legume intercropping has been shown to enhance soil quality, porosity and soil tilth (Keisling *et al*., 1994) and tillage is facilitated through reduced draoght of soil-engaging equipment, where legume cropping can substantially influence soil bulk density, aggregate stability and/or penetration resistance, this is also likely to impact on root development and the ability of cotton to respond to improved nutrient availability. With continuous 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, it 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 unprecedented highs whilst supply has been limited when it is needed most (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, yield and N-uptake of cotton crop.

Materials and Methods

The series of field experiments were carried at Students Farm, Sindh Agriculture University Tandojam, Pakistan in randomized complete block design with factorial arrangement having three replications and repeated in 2nd year. The details of treatments used are as under.

Crop sequences=02
C_1= Cotton (before legume) and C_2= Cotton (after legume)

Fertility levels=03
F_1=150-50, F_2=100-50 and F_3=150-50 NP Kg ha^1

Cultural practices: The cotton variety Qalandri was sown before legume (berseem) and after legume. Urea and Diammonium 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. However, in case of berseem (legumes), the recommended NP fertilizers were applied. The crop was kept free of weeds. Plant protection measures were adopted when ever necessary. The data collected were analyzed following the procedures of Gomez & Gomez (1984).

Determinations
Soil texture: By Bouyoucos Hydrometer as described by Kanwar & Chopra (1959).
Ec (dSm^{-1}): By Ec meter
pH: by digital pH meter.
Organic matter (%): By Walkely-Black method as described by Jackson (1958).
Available phosphorus: By method of Olson *et al*., (1954).
Extractable potassium: By extraction with 1N Ammonium acetate followed by Flame photometer as described by Jackson (1958).
N-uptake in (kg ha^{-1}): Total dry matter x N in plant^{-1} x 100

Results and Discussion

Soil analysis: The chemical analysis of the soil before experiment showed that soil was sandy clay loam in texture, calcareous in nature ($CaCO_3$ 11.20%), alkaline in reaction (pH 8.19), non-saline (EC 0.21 dSm^{-1}), low in organic matter (0.82%) and nitrogen (0.047%), medium in available phosphorus (6.17ppm) and high in potassium (127.50 ppm).

Plant height (cm): Fertilizer levels significantly increased plant height. Subsequent increase in N levels from 50 to 150 kg ha^{-1} resulted in proportionate increase in the plant height. The taller plants were recorded in the treatments where 150 kg N ha^{-1} was applied. It is well known fact that nitrogen application boosts crop growth and development. The increased plant height is the result of flamboyant and vigorous plant growth. The crop sequences also highly significantly affected plant height. Maximum plant height was recorded in the crop sequence where preceding crop was a legume. This may also be due to provision of additional residual fertility left over by bacterial activity of the preceding crop. These results are in agreement with those of Rochester *et al.,* (2001) that plant height in cotton is related to nitrogen application.

Monopodial and sympodial branches plant^{-1}: A gradual increase in monopodial and sympodial branches with the subsequent increases in the nitrogen application rates was noted. Maximum number of monopodial branches was observed in experimental units where 150 kg N ha^{-1} was applied. Nitrogen played its part in the exuberant vegetative growth of the plants. Monopodial and sympodial branches are also vegetative branches and showed better response to the increased nitrogen levels. As for as the results for the effect of crop sequences on branches are concerned, higher number of branches were counted in the crop sequence where preceding crop was a leguminous crop. The residual fertility caused vigorous growth of cotton crop with increased branches plant^{-1}. Thus, the maximum number of branches was produced in the crop year where the preceding crop was legume.

Bolls plant^{-1}: Maximum bolls plant^{-1} were produced by the higher nitrogen application. The reason for increased number of bolls plant^{-1} with increased N fertilizer levels may be due to the active role of N in the growth and development of cotton plant. Sufficient amount of N when applied is utilized by the plants in photosynthesis process and the resultant photosynthates are diverted to different parts of the plant where they are needed as sink. Suitable amounts of photosynthates when provided at boll formation stage result into proliferation of bolls. Crop sequences also highly significantly affected the number of bolls plant^{-1}. Maximum boll number was recorded in the crop sequence in which preceding crop was a leguminous crop. This can be due to the additional supply of residual fertility deposited in the soil by the symbiotic bacterial activity by the preceding leguminous crop. Similar results were reported by Ram Parkash & Mangal Prasad (2000) that boll production was significantly higher with the application of adequate nitrogen and when crop is grown in the field left by legume crop.

Seed index (g): The seed index increased significantly when the nitrogen level was doubled from 50 to 100 kg ha^{-1}, there after it remained stagnant with the additional increase of 50 kg N ha^{-1}. This clearly indicates that N enhances the photosynthetic activity and the partition of photosynthates effectively up to the level of 100 kg N ha^{-1}, whereas, the increment in nitrogen levels above the optimum dose of 100 kg could not induce further partition of photosynthates towards the seed sink. The bolder seeds were obtained from the crop sequence in which cotton was planted after berseem. The residual fertility from the preceding leguminous crop was utilized by the cotton plants with supplement nitrogen application. Similar results are reported by Entry *et al.,* (1996) that seed index is greatly affected by nitrogen (source), which contribute to seed (sink) filling and thus optimum application enhances the seed index of the crop.

Seed cotton yield (Kg ha^{-1}): Seed cotton yield increased consistently with every increase of 50 kg in N application rate. Maximum seed cotton yield ha^{-1} was obtained from the treatments where 150 kg nitrogen was incorporated. Nitrogen is the primary ingredient in the raw food of the plant, which is ultimately processed through photosynthesis and chemical reactions and finally converted into the photosynthates which are the primary prerequisites in all the physiological processes undergoing in the plant body. Thus, more the available nitrogen more will be the partition of photosynthetic outcomes towards final seed cotton yield. Entry *et al.,* (1996); Khan & Ahmed (1996); Milap *et al.,* (1996); Ram Parkash & Mangal Prasad, 2000) also pleaded the role of nitrogen in enhancing seed cotton yield. Crop sequences also had a highly significant effect on seed cotton yield. Higher yields were procured from the crop sequences where preceding crop was a leguminous one. The interaction of nitrogen with crop sequence was also significant. Higher seed cotton yield was achieved from the plots were 150 kg N ha^{-1} was applied and the crop was planted after berseem. Inorganic nitrogen fertilizer supplemented with residual fertility of the soil from the proceeding leguminous crop resulted in higher seed cotton yields because both the fertility ingredients were effectively utilized by the cotton crop. These results are supported by Singh & Deo (1998); Rochester *et al.,* (2001) who reported that cotton-wheat crop sequence produced highest yield when planted after legumes. Das *et al.,* (2004) was also of the opinion that integrated application of organic and inorganic fertilizer would result into higher productivity and sustainability of the cotton-wheat cropping system. The effect of years on seed cotton yield was also highly significant. Substantially higher yields were obtained in the 1st year as compared the 2nd year due to favorable climatic conditions during growth period of cotton in the preceding year resulted in exuberant and vigorous crop growth which in turn increased seed cotton yield.

GOT (%): Application of fertilizers increased GOT of the cotton crop. Maximum GOT was noted in the higher fertilizer level of 150 kg N ha^{-1}. Milap *et al.,* (1996) also reported that application of N linearly increased ginning out turn and other crop parameters. The crop sequences which included legumes significantly produced higher GOT. Legumes in the rotation are used to increase the available soil nitrogen because legumes are a large, diverse and agriculturally important family of plants (Heywood, 1971). The benefits of the legumes in cropping systems are well established. Peoples & Craswell (1992) and Giller (2001) observed that legumes can fix substantial amounts 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).

Table 1. Cotton plant traits as affected by fertilizer levels and crop sequences.

Fertilizer levels NP Kg ha^{-1}	Years (Y)				Average
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
Plant height (cm)					
50 – 50	77.52	87.55	65.80	73.55	76.11
100 – 50	102.50	105.05	96.95	98.80	100.83
150 – 50	103.90	105.62	99.80	101.20	102.63
Average	94.64	99.41	87.52	91.18	--

CV = 4.81%

	S.E	LSD1	LSD 2
Year (Y)	0.9143	1.8561	2.4960
Sequence (C)	0.9143	1.8561	2.4960
Nitrogen level (N)	1.1198	2.2732	-
Y x C x N	0.8441	-	-

Monopodial branches plant^{-1}					
50 – 50	0.95	1.75	0.97	1.22	1.22
100 – 50	1.85	2.80	1.40	2.20	2.06
150 – 50	2.42	3.50	1.80	2.70	2.61
Average	1.75	2.68	1.39	2.04	--

CV = 15.42%

	S.E	LSD1	LSD 2
Year (Y)	0.0619	0.1257	0.1689
Sequence ©	0.0619	0.1257	0.1689
Nitrogen level (N)	0.0758	0.1538	0.2069
Y x C x N	0.1515	0.3075	-

Sympodial branches plant^{-1}					
50 – 50	9.62	12.05	7.50	9.50	9.67
100 – 50	13.60	14.30	8.30	11.80	12.00
150 – 50	14.15	15.95	11.30	13.40	13.70
Average	12.46	14.10	9.03	11.57	--

CV = 6.97%

	S.E	LSD 1	LSD2
Year (Y)	0.1678	0.3406	0.4581
Sequence ©	0.1678	0.3406	0.4581
Nitrogen level (N)	0.2055	0.4172	0.5610
Y x C x N	0.4109	-	-

Table 1. (Cont'd.).

Fertilizer levels NP Kg ha^{-1}	Years (Y)				Average
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
Bolls plant^{-1}					
50 – 50	17.12	20.00	15.50	18.50	17.66
100 – 50	24.50	26.50	20.20	23.79	23.79
150 – 50	26.00	28.00	24.80	26.80	26.40
Average	22.54	24.83	20.17	22.92	--

CV = 8.187%

	S.E	LSD1	LSD2
Year (Y)	0.3776	0.7665	1.0308
Sequence ©	0.3776	0.7665	1.0308
Nitrogen level (N)	0.4625	0.9388	1.2626
Y x C x N	0.9248	-	-

Seed index (g)					
50 – 50	3.65	4.75	3.00	4.30	3.93
100 – 50	5.95	6.65	5.80	6.40	6.20
150 – 50	6.35	7.75	6.00	7.20	6.83
Average	5.32	6.38	4.93	5.84	--

CV = 7.50%

	S.E	LSD1	LSD2
Year (Y)	0.0865	0.1756	0.2361
Sequence ©	0.0865	0.1756	1.2361
Nitrogen level (N)	0.1059	0.2149	0.28910
Y x C x N	0.2119	-	-

Seed yield kg ha^{-1}					
50 – 50	1202.50	1654.00	950.00	1348.00	1288.63
100 – 50	2360.00	2672.50	1750.00	2040.50	2205.75
150 – 50	2575.50	2957.50	2180.00	2440.00	2538.25
Average	2046.00	2428.00	1626.67	1942.83	--

CV = 7.51%

	S.E	LSD1	LSD2
Year (Y)	30.8462	62.6177	84.2101
Sequence ©	30.8462	62.6177	84.2101
Nitrogen level (N)	37.7787	76.6907	103.1359
Y x C x N	75.5574	-	-

Table 1. (Cont'd.).

Fertilizer levels NP Kg ha^{-1}	Years (Y)				Average
	Year-1		Year-2		
	Crop sequence (C)				
	C_1 (Before legume)	C_2 (After legume)	C_1 (Before legume)	C_2 (After legume)	
GOT (%)					
50 – 50	33.50	33.70	33.40	33.60	33.55
100 – 50	33.80	34.60	33.70	34.20	34.07
150 – 50	34.20	35.10	33.90	35.10	34.57
Average	33.83	34.47	33.67	34.30	

C.V = 1.7%

	S.E	LSD1	LSD2
Years (Y)	0.1181	--	--
Sequence	0.1181	--	--
Nitrogen levels (N)	0.1447	0.4163	0.5593
Y x C x N	0.2893	0.8327	1.1190

Fertilizer levels NP Kg ha^{-1}	Year-1 C_1	Year-1 C_2	Year-2 C_1	Year-2 C_2	Average
Staple length (mm)					
50 – 50	28.50	28.53	27.50	27.90	28.11
100 – 50	28.60	28.90	27.70	28.40	28.40
150 – 50	28.60	29.10	28.10	28.80	28.65
Average	28.56	28.83	27.76	28.36	--

C.V = 1.79

	S.E	LSD1	LSD2
Years (Y)	0.1038		
Sequence	0.1038		
Nitrogen levels (N)	0.1272	0.3665	-
Y x C x N	0.2545	-	-

Fertilizer levels NP Kg ha^{-1}	Year-1 C_1	Year-1 C_2	Year-2 C_1	Year-2 C_2	Average
Oil content (%)					
50 – 50	21.30	22.00	21.50	21.53	21.58
100 – 50	22.50	22.83	21.80	22.63	22.43
150 – 50	23.00	23.80	22.60	23.00	23.10
Average	22.26	22.87	21.96	22.37	--

C.V = 1.77

	S.E	LSD1	LSD2
Years (Y)	0.0810		
Sequence	0.0810		
Nitrogen levels (N)	0.0992	0.2858	0.3892
Y x C x N	0.1981	-	-

Fertilizer levels NP Kg ha^{-1}	Year-1 C_1	Year-1 C_2	Year-2 C_1	Year-2 C_2	Average
Nitrogen uptake (kg ha^{-1})					
50 – 50	38.08	62.50	44.20	55.22	50.00
100 – 50	69.30	92.51	72.36	88.61	80.69
150 – 50	94.84	118.50	116.00	124.41	113.43
Average	67.40	91.17	77.52	89.41	--

Staple length (mm): As the fertility level increased, the staple length also increased and was found maximum on 150-50 NP kg ha^{-1}. Ahmad (1998) and Ahmad (2000) also reported that among the plant nutrients, nitrogen play a very important role in crop productivity and its deficiency is one of the major yield limiting factors for crop production (McDonald, 1989; Shah *et al*., 2003). With continuous 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). The results of the study also revealed that legume incorporation enhanced the cotton staple length and crop sown after leguminous crop exhibited maximum staple length. Thus, to keep the soil productive and sustainable one have to continuously replenish soil organic matter through including legumes in crop rotations and retaining crop residues (Giller, 2001). Thus, the systems that incorporate the cultivation of leguminous crops should be developed for sustainable crop productivity (Sharif *et al.,* 2002; Tarafdar & Claassen, 2003).

Oil content (%): The oil content of cotton seed did not show much response to fertilizers and residual effect of leguminous crops. However, oil content values recorded higher in fractions. This might be due to soil and environmental conditions which caused positive association with oil content of crop, which in broad terms is negligible.

Nitrogen uptake in cotton (kg ha^{-1}): The N rate proliferated from 50-150 kg ha^{-1}, the uptake of N increased linearly. The maximum N-uptake (113.43 kg ha^{-1}) was observed under 150-50 Kg NP ha^{-1}. The N-uptake decreased upto 50.00 kg ha^{-1} as the fertilizer levels decreased. It was further observed that N- uptakes before legume crop were 67.40 and 77.52 Kg ha^{-1} in year-1 and 2 respectively and increased linearly (91.17 and 89.41 kg ha^{-1}) in both the years in the field when cotton was planted after berseem. Prakash *et al.,* (2001); Rameshwar (2001) and Ravankar *et al.,* (2001) also observed that lower doses of nutrients decreased the yields as well as nutrient uptake by the crops.

Conclusions

It is concluded that nitrogen fertilizer is essential nutrients which enhance growth, yield and N-uptake of the cotton crop. The application of 150-50 NP kg ha^{-1} found sufficient dose for satisfactory yield and qualitative characters. The continuous cropping in the sequence of wheat-cotton will be avoided. It is suggested that for maintenance of soil fertility and enhancement of crop productivity the inclusion of leguminous crop at least once in a two year cropping sequence is necessary.

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Growth and yield response of cotton to different nitrogen levels and plant spacing was studied at farmerâ€™s field at Tandlianwala, Faisalabad. The experiment comprised three plant spacings viz.Â More nitrogen was taken up by the plants in case of N 3 where it was applied in maximum amount. Nitrogen uptake decreased significantly with the decrease in rate of nitrogen application.Â Plant spacing had non-significant effect on nitrogen uptake, nitrogen uptake efficiency and nitrogen use efficiency. The final yield is the function of combined effect of all the yield components under a particular set of environmental conditions. The results suggested that legumes in the tested rotation do not need supplemental N fertilization, particularly if combining GM and F. The use of composted farmyard manure should be considered in a long-term fertilization plan for cereals, to allow a higher efficiency in N use. The residual effect of fertilization over time, along with the site-specific pedo-climatic conditions, should also be considered.Â Moreover, N left in the soil after the legume crop was determined as the difference between the N supply and N uptake. Calculation of N-fixation values (BNF, biologically nitrogen fixation) was made based on the formula proposed by HÃ¸gh-Jensen et al. [27], modified by Hansen et al. Furthermore, differences in plant genotypes, environmental interactions and management systems will influence the supply and demand by the plant for N (Angus et al., 2001).Â 2.3 Role of N in plant growth. N is an important factor limiting plant growth and productivity worldwide. Plants are provided N from both atmospheric air and soil minerals.Â The uptake of N-fertilizers occurs when N is readily available in the soil solution at the root zone and when plant demand for N exists. When these conditions are met, NO3- and NH4+ transporter systems (see below) are expressed across various cell types across the roots for initial uptake and redistribution across the root to the stele (Daniel-Vedele et al., 1998; Tsay et al., 2007).