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Yield of Wheat, Cotton, Berseem and Soybean Under Different Crop Sequences and Fertility Regimes

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Abstract: The series of field experiments were laid out during 1989-1990 and 1990-1991 at Students Farm, Sindh Agriculture University Tandojam, Pakistan. The crop sequences were: C1= wheat-soybean-wheat and C2= cotton-berseem-cotton. The fertilizer levels for cotton and wheat were: 50-50, 100-50 and 150-50 NP kg ha^{-1} and for legumes: 0-50, 25-50 and 50-50 NP kg ha^{-1}. The general observation in the experiments showed that increasing rate of N fertilizer application significantly enhanced grain yield in all sequences and years. In wheat-soybean-wheat sequence, the maximum wheat grain yield (3198.19 kg ha^{-1}) was obtained when crop was fertilized with 150-50 kg NP ha^{-1}. The difference in grain yield between the two year was negligible and might be due to climatic conditions, however, maximum wheat grain yield (2645.63 kg ha^{-1}) was obtained during 1989-90 and 2522.33 kg ha^{-1} grain yield was obtained during 1990-91 with the application of 150-50 kg NP ha^{-1}. In wheat-soybean-wheat sequence it was noted that wheat planted after soybean produced highest grain yield compared to wheat grown before soybean. In cotton-berseem-cotton sequence, the fertilizer dose of 150-50 kg NP ha^{-1} was found superior for maximum (2538.235 kg ha^{-1}) seed cotton yield. The cotton planted in 1989-90 produced satisfactory seed cotton yield of 2237 kg ha^{-1} compared to 1990-91 planted cotton. Yearly observation for fertility regimes showed non-significant differences in the seed cotton yield values. Cotton planted after berseem exhibited higher (2185.42 kg ha^{-1}) seed cotton yield compared to cotton planted before berseem (1836.33 kg ha^{-1}). Berseem in the crop sequence with cotton recorded maximum green fodder yield of 16065.50 kg ha^{-1} in the plots fertilized with 50-50 kg NP ha^{-1}. Soybean used in crop sequence recorded maximum seed yield (1536 kg ha^{-1}) under 50-50 kg NP ha^{-1}. In the two year study, it was concluded that increased crop productivity could be obtained by incorporation of leguminous crop at least once in a cropping sequence, because legume crops enrich soil fertility by fixing free environmental nitrogen in their root nodules, which in turn supply residual food nutrients in the succeeding crop. It is recommended that both wheat-soybean-wheat and cotton-berseem-cotton sequences with the incorporation of 150-50 NP kg ha^{-1} seems to be beneficial for achieving satisfactory target yields.

Key words: Legumes, crop, sequence, cotton, wheat, berseem, soybean, yield, fertilizers

INTRODUCTION

Although the first written records of legume rotations trace back to the Roman Empire, it was not until the European feudal times that legume rotation was practiced to a great extent. This practice of using grasses and legumes as both rotation crop and livestock fodder reached its zenith in the ley farming system of Europe (Heath and Kaiser, 1985).

Crop rotation is an integral part of the crop production system. A well-planned crop rotation reduces insect pest and disease and ameliorate soil structure and organic matter levels. The organic matter is the key component of soil which influences plant growth through its effects on the physical, chemical and biological properties of soil and provides carbon as energy source to N-fixing bacteria, facilitate nutrient uptake, improve chlorophyll synthesis and seed germination (Allen and Allen, 1981). Legumes in the rotation can be used to increase the available soil nitrogen. The most important legume species belong to a small group of herbaceous crop and forage species. The main trait to these legumes is the ability to fix atmospheric nitrogen and convert it to a useable form for plant growth (Allen and Allen, 1981). Today, forage legume species are assigned crop farming depending on their plant structures and abilities (Heath *et al*., 1985; Ball *et al*., 1993). Upright species such as alfalfa (*Medicago sativa* L.) are best suited to produce hay and silage in a mono cropping system (Blaser *et al*., 1973). The amount of nitrogen produced by legumes depends on the species used, the success of seed inoculation at planting time and the total biomass produced. In a study at Georgia, winter cover crops such as hairy vetch (*V. villosa* Roth) and crimson clover (*T. incarnatum* L.) were found to replace all of the fertilizer nitrogen needed to produce good non-irrigated yields of grain sorghum (*S. bicolor* L.) and almost two-thirds of the nitrogen required for good yields

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of maize, *Zea mays* L. (McVay *et al.*, 1989). There was also an improvement in soil physical properties such as water soluble aggregates and water infiltration rate when plots with forage legumes were incorporated (Shaffer, 2002). Das *et al.* (2004) reported that integrated application of organic and inorganic fertilizer is recommend for high productivity and sustainability of the cotton-wheat system. It is estimated that various crop rotations, reduces the degree of soil erosion by more than 50% when compared to continuous planting of corn (Weiser *et al.*, 1985). The expected reduction in soil erosion would be even greater on steeper slopes (Paterson, 2003). Looking the importance of crop sequence, the series of field experiments were conducted to observe the enhanced crop productivity of fibre and cereal crops by incorporation the legumes in the sequence.

MATERIALS AND METHODS

The series of field experiments were laid out during 1989-1990 and 1990-1991 at Students Farm, Sindh Agriculture University Tandojam, Pakistan in randomized complete block design with factorial arrangement having four replications. The details of treatments are as under.

Crop sequences

C1 = Wheat-Soybean-Wheat
C2 = Cotton-Berseem-Cotton

Fertilizer levels
For cotton and wheat: 50-50, 100-50 and 150-50 NP kg ha^{-1}

For legumes: 0-50, 25-50 and 50-50 NP kg ha^{-1}

Fertilization: Urea and DAP were used as the source of nitrogen and phosphorus, respectively. All the phosphorus and half of the nitrogen was side drilled at sowing time and the remaining nitrogen was split applied during 2nd, 3rd and 4th irrigations.

Cultural practices: The experiments were kept free from weeds, insects and pests. All the recommended agronomic practices were adopted as per crop requirement.

RESULTS

Wheat grain yield (kg ha^{-1}): The results revealed that increasing rate of N fertilizer application significantly enhanced grain yield in all sequences and years. Maximum grain yield (3198.19 kg ha^{-1}) was obtained when crop was fertilized with 150-50 kg NP ha^{-1} and 2910.25 kg ha^{-1} grain yield was obtained at 100-50 NP kg ha^{-1}. The minimum grain yield (1643.50 kg ha^{-1}) was noted at lowest rate of 50-50 NP kg ha^{-1}. The combined interaction of years x crop sequence x nitrogen (Y x C x N) indicated that highest grain yield (3330 kg ha^{-1}) was obtained from 150-50 kg NP ha^{-1} with wheat planted after soybean during 1989-90. Overall, fertilizer and crop sequence has got great response for grain yield (Table 1).

The interaction of nitrogen and year (N x Y) indicated that maximum grain yield (2645.63 kg ha^{-1}) was obtained during 1989-90 and 2522.33 kg ha^{-1} grain yield was obtained during 1990-91. The differences in grain yield between the two year were negligible and might be due to similar climatic conditions (Table 2).

Crop sequence data revealed that grain yield differed significantly among crop sequences. However, wheat planted after soybean produced highest grain yield of 2712.23 kg ha^{-1} compared to wheat grown before soybean i.e., 2455.03 kg ha^{-1}(Table 3).

The interaction of years x crop sequence (YxC) showed that maximum (2763.33 kg ha^{-1}) grain yield was obtained from wheat planted after soybean in 1989-90 closely followed by the year 1990-91 which displayed 2661.33 kg ha^{-1} grain yield. However, when wheat planted before soybean crop displayed 2527.92 and 2383.33 kg ha^{-1} grain yield for both years, respectively (Table 4).

Table 1: Grain yield (kg ha^{-1}) of wheat as affected by inorganic nitrogen and crop sequence two years

	Years				
	Year-1 (1989-90)		Year-2(1990-91)		
	Crop sequence				
Nitrogen levels (N kg ha^{-1})	C1 (Before soybean)	C2 (After soybean)	C1 (Before soybean)	C2 (After soybean)	Average
50	1554.00	1850.00	1390.00	1780.00	1643.50
100	2821.00	3110.00	2750.00	2960.00	2910.25
150	3208.75	3330.00	3010.00	3244.00	3198.19
Average	2527.92	2763.33	2383.33	2661.33	--

CV% = 8.04	SE	LSD5 (%)	LSD1 (%)
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 2: Interaction of nitrogen x year for wheat grain yield (kg ha^{-1})

Nitrogen levels (N kg ha^{-1})	Years: Year-1 (1989-90)	Year-2 (1990-91)	Average
50	1702.00	1585.00	1643.50
100	2965.50	2855.00	2910.25
150	3269.38	3127.00	3198.20
Average	2645.63	2522.33	--

CV% = 8.04%, SE= 73.4256, LSD 5%= 149.0527, LSD 1%=200.4518

Table 3: Crop sequence and nitrogen (NxC) interaction effect on grain yield of wheat (kg ha^{-1})

Nitrogen levels (N kg ha^{-1})	Crop sequence C1	C2	Average
50	1472.00	1815.00	1643.50
100	2785.50	3035.00	2910.25
150	3109.40	3287.00	3198.00
Average	2455.25	2712.33	--

CV% = 8.04%, SE = 73.4256, LSD 5% = 149.0527, LSD 1% = 200.4518

Table 4: Crop sequence and year (CxY) interaction effect on grain yield of wheat (kg ha^{-1})

Crop sequences	Years Year-1 (1989-90)	Year-2 (1990-91)	Average
C1	2527.92	2383.33	2455.63
C2	2763.33	2661.33	2712.33
Average	2645.63	2522.33	--

CV% = 8.04%, SE= 59.9518, LSD 5% = 121.7021, LSD 1% = 163.6684

Seed cotton yield (kg ha^{-1}): It was observed that fertilizer rates differed significantly for seed cotton yield. The fertilizer dose of 150-50 kg NP ha^{-1} produced maximum (2538.235 kg ha^{-1}) seed cotton yield. Data further indicated that 100-50 kg NP ha^{-1} produced 2205.75 kg ha^{-1} seed cotton yield. The lowest yield (1288.63 kg ha^{-1}) was obtained when lower rate of 50-50 kg NP ha^{-1} was applied. The cotton planted in 1989-90 produced highest (2237 kg ha^{-1}) seed cotton yield compared to 1990-91 cotton, which recorded 1784.75 kg ha^{-1}) seed cotton yield (Table 5).

The interaction of N x Y showed that 150-50 kg NP ha^{-1} exhibited maximum (2766.50 kg ha^{-1}) seed cotton yield in 1989-90 crop and the lowest seed cotton yield was noted in both years at 50-50 kg NP ha^{-1}, which was 1428.25 and 1449 kg ha^{-1}, respectively (Table 6).

Cotton planted after berseem recorded 2185.42 kg ha^{-1} seed cotton yield compared to cotton planted before berseem which produced 1836.33 kg ha^{-1} seed cotton yield. In the interaction of NXC, the application of 150-50 kg NP ha^{-1} produced maximum (2698.75 kg ha^{-1}) seed cotton yield, when cotton planted after berseem. The lowest seed cotton yield (1076.25 kg ha^{-1}) was obtained at 50-50 kg NP ha^{-1} when cotton planted before berseem (Table 7).

The maximum (2428 kg ha^{-1}) seed cotton yield was obtained in 1989-90, when cotton planted after berseem lowest seed cotton was obtained in 1990-91, when cotton planted before berseem (Table 8).

Green fodder yield of berseem (kg ha^{-1}): The green fodder yield differed significantly. Highest green fodder yield (18197.50 kg ha^{-1}) was obtained from 3rd cutting followed by 4th cutting, which recorded (17175.33 kg ha^{-1}) green fodder yield. Under N levels, maximum green fodder yield (16065.50 kg ha^{-1}) was obtained when 50-50 kg NP ha^{-1} was applied closely followed by 25-50 kg NP ha^{-1}, which produced 15728 kg ha^{-1} green fodder yield. The lowest green fodder yield (14652.50 kg ha^{-1}) was obtained under 0-50 kg P ha^{-1} (Table 9). Estimates of available nitrogen of alfalfa to succeeding corn crop were as high as 180 kg ha^{-1}, (Baldock and Musgrave, 1980); Hester Man *et al.* (1987) suggested that N credit commonly attributed to legume in crop rotations may be inflated by a much as 132%.

Table 5: Average seed cotton yield (kg ha^{-1}) as affected by inorganic nitrogen and crop sequence two years

Nitrogen levels (N kg ha^{-1})	Years: Year-1 (1989-90) Crop sequence C1(Before berseem)	C2(After berseem)	Year-2 (1990-91) C1 (Before berseem)	C2 (After berseem)	Average
50	1202.50	1654.00	950.00	1348.00	1288.63
100	2360.00	2672.50	1750.00	2040.50	2205.75
150	2575.50	2957.50	2180.00	2440.00	2538.25
Average	2046.00	2428.00	1626.67	1942.83	--

CV%7.51	SE	LSD @ 5%	LSD@1%
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 6: Interaction of nitrogen x year for seed cotton yield (kg ha^{-1})

Nitrogen levels (N 0 kg ha^{-1})	Years Year-1 (1989-90)	Year-2 (1990-91)	Average
50	1428.25	1149.00	1288.63
100	2516.25	1895.25	2205.75
150	2766.50	2310.00	2538.25
Average	2237.00	1784.75	--

CV% = 7.51%, SE = 53.4272, LSD 5% = 108.4572, LSD 1% = 145.8563

Table 7: Crop sequence and nitrogen (NxC) interaction effect on seed cotton yield (kg ha^{-1})

Nitrogen levels (N 0 kg ha^{-1})	Years C1	C2	Average
50	1076.25	1501.00	1288.63
100	2055.00	2356.50	2205.75
150	2377.75	2698.75	2538.25
Average	1836.33	2185.00	--

CV% = 7.51%, SE = 53.4272

Table 8: Crop sequence and year (CxY) interaction effect on seed cotton yield (kg ha^{-1}).

Crop sequence	Years Year-1 (1989-90)	Year-2 (1990-91)	Average
C1	2046.00	1626.67	1836.34
C2	2428.00	1942.83	2185.42
Average	2237.00	1784.75	--

CV% = 7.51%, SE = 43.6231

Table 9: Green fodder yield (kg ha^{-1}) of berseem at various cuttings as affected by nitrogen levels

Nitrogen levels (N-Pkg ha^{-1})	Cuttings 1st	2nd	3rd	4th	5th	Average
0-50	12850.00	15200.00	17502.00	14140.00	11510.00	14652.00
25-50	14100.00	16180.00	18300.00	17750.00	12310.00	15728.00
50-50	15958.00	15560.00	18730.00	17630.00	12450.00	16065.00
Average	14302.00	15647.00	18197.00	17175.00	12090.00	

CV = 11.18%, SE for cutting mean = 499.8180, LSD 5% = 1297.02, LSD 1% = 1899.8082, SE for nitrogen levels mean = 387.1574, LSD 5% = 1248.58, SE for C x N = 865.7102

Table 10: Seed yield (kg ha^{-1}) of soybean as affected by nitrogen levels

Nitrogen levels (N-P kg ha^{-1})	Average
0-50	1340.00
25-50	1450.00
50-50	1536.00

CV = 13.11%, SE for nitrogen mean = 94.5477

Seed yield of soybean (kg ha^{-1}): The maximum seed yield (1536 kg ha^{-1}) was produced when 50-50 kg NP ha^{-1} was applied closely followed by 25-50 kg NP ha^{-1}, which produced 1450 kg ha^{-1} seed yield. However, minimum seed yield (1340 kg ha^{-1}) was obtained when 0-50 kg NP ha^{-1} was given. It was observed that fertilizer treatment respondent less in seed yield of soybean (Table 10).

DISCUSSION

Nehra *et al.* (2001) observed that nitrogen is a nutrient which enhances vegetative growth of the crop and have positive relationship with yield. Bazitov (2000) reports that the manure fertilizer and fertilizer systems increased the wheat yields from 76-112% as compared to the control plots where no manure or fertilizers was used. Similarly, Bhagat (2001) reported that wheat crop with moderate fertilizer rate displayed higher grain yield than farmers practice. Penchev *et al.* (2000) reported high yields of wheat crop after a leguminous crop such as chickpeas. Das *et al.* (2004) reported that integrated application of organic and inorganic fertilizer for obtaining high productivity and sustainability of the cotton-wheat system. Parkash and Prasad (2000) have also pleaded the rate of Nitrogen in enhancing seed cotton yield. But, Rochester *et al.* (2001) reported that cotton-wheat produced highest yield when planted after legumes.

Seed cotton yield ha^{-1} 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 applied. Nitrogen fertilizer is utilized by the cotton plant for its growth and development. It makes the primary ingredient in the raw food of the plant, which is ultimately processed through photosynthesis and chemical reactions underlying that process and finally converted into the photosynthetes which are the primary pre-requisites 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 and Munir (1996), Milap *et al.* (1996) and Parkash and Prasad (2000) have 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 proceeding 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 yields because both the fertility ingredients were effectively utilized by the cotton crop. These results are supported by Entry *et al.* (1996), Milap *et al.* (1996), Singh and Deo (1998) and Rochester *et al.* (2001) who reported that cotton/ wheat 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 system. The effect of years on seed cotton yield was also highly significant. Substantially higher yields were obtained in the 1989-1990 as compared with the year 1990-1991, more favorable climatic conditions during growth period of cotton in the preceding year resulted in exuberant and vigorous crop growth which may have increased seed cotton yields.

CONCLUSIONS

Soil fertility has declined due to continuous cropping of cotton-wheat sequence over the years. The major conflict in the cotton-wheat cropping system is the prolonged harvesting of cotton resulting in late planting of wheat causing its yield reduction. Whereas, continuous cropping with cereals under the present conditions has/had negative effects on soil fertility and can lead to an increase in soil-borne pests and troublesome weeds. There are opportunities to integrate appropriate legume-based technologies into the farming systems based on an identification of inherent nitrogen-release patterns. The application of nitrogen additively increases yields of various crops used in the crop sequences. Therefore the wheat-legume rotation seems to be the best practice and is recommended for the semiarid regions of Sindh.

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