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WHEAT (*TRITICUM AESTIVUM* L.) STAND ESTABLISHMENT IN LEGUME AND NON-LEGUME BASED CROPPING SYSTEMS

Muhammad Aslam [a]*, *N I Hashmi* [b], *A Majid* [a], *Iftikhar Ahmad* [a] *and A Razzaq* [a]

[a] *Wheat Programme, National Agricultural Research Centre, Islamabad, Pakistan*
[b] *Pakistan Agricultural Research Council, Islamabad, Pakistan*

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Wheat stand establishment behaviour was studied in different cropping systems under rainfed conditions, during 1992-94. On the basis of wheat emergence (m^{-2}) and emergence rate index, two distinct groups of cropping systems were observed. The first group included fallow-wheat, mashbean-wheat, mungbean-wheat and cowpea-wheat systems whereas the second included maize-wheat, sorghum-wheat, millet-wheat, sunflower wheat and soy bean-wheat systems. Wheat stand establishment was significantly ($P<0.05$) higher in the first group than in the second group. In Rabi 1992-93 wheat emergence was completed in a short period and emergence rate index was higher than that for 1993-94 due to dry weather. Overall, there was significantly ($P<0.05$) better residual soil moisture (0-15 cm layer) in fallow-wheat, mashbean-wheat, mungbean-wheat and cowpea-wheat cropping systems than other systems under study during both the years.

Key words : Cropping systems, Rainfed conditions, *Triticum aestivum* L., Leguminous plants.

Introduction

Rotation of crops is an important component of sustainable farming system. Generaly, when cereals are rotated with legumes, the yields are usually higher due to contribution of N from leguminous crops.

Wheat *(Triticum aestivum L.)* stand establishment is a critical problem in rainfed areas of Pothwar. In these areas, at wheat sowing time relatively less amount of soil moisture prevails in the seed zone and is also drying rapidly. Inadequate and erratic rains at the sowing time of wheat result in poor germination and seedling establishment. Success of wheat establishment mainly depends on conserved summer (Kharif) moisture and the current rains. Kharif fallowing is a common practice to conserve moisture and in most cases fallow system can be sustained by operating large amount of tillage practices (Zahid *et al* 1991). Wheat seeds have to attain a specific moisture content to germinate. Germination occurs in a short time at high moisture, otherwise it will be delayed progressively as the soil moisture is lowered from field capacity (Hillel 1972). Designed cropping systems make effective use of land and other resources. However, under rainfed conditions cropping systems that provide enough soil moisture required for better wheat establishment would be of prime importance.

Studies were therefore, conducted with emphasis on wheat stand establishment in different cropping systems. For this purpose wheat emergence m^{-2}, emergence rate index and soil moisture contents were measured in different legume and non-legume based cropping systms. Fallow-wheat system was included in this study as a benchmark to compare other cropping systems.

*Author for correspondence

Materials and Methods

The study was conducted at the National Agricultural Research Centre (NARC) Islamabad during 1992-94. The experimental site is located at longitude 73° 08 East and latitude 33° 42 N, 510 meters above sea level. The soil of the experimental site was low in organic matter, phosphorus and nitrogen however, potassium level was adequate (Soltanpour and Workman 1974). The pH of the loam soil was 8.0. Nine cropping systems, fallow-wheat, maize-wheat, sorghum-wheat, millet wheat, sunflower-wheat, mashbean-wheat, mungbean-wheat, cowpea-wheat and soybean-wheat were studied.

Cropping systms were arranged in a randomized complete block design (RCBD) using four replications (Patterson 1964; Cady 1991). The trial had two cycles and every cycle had two phases i.e. Kharif and Rabi. Experiment was stablished by laying out 38 plots. Each plot was 5 meters wide and 10 meters long. Experiment was initiated in Kharif 1992. After harvest of Kharif crops, wheat was planted during "Rabi" 1992-93 in all plots. This completed one cycle of the cropping systems trial. In the second cycle, the trial was repeated in the same fashion. In both cycles, all agronomic practices were kept uniform. In Kharif phase the crops under study were raised according to the recommendations of the area. In case of wheat, land preparation was done by using disk, followed by the cultivator and then the surface was planked to ensure a firm seed bed. Nitrogen and phosphorus, each at the rate of 80 kg ha^{-1}, were applied before sowing and incorporated by cultivation and planking. Wheat cultivar "Rohtas" was planted on 10th and 8th November, during 1992-93 and 1993-94, respectively with a drill. Seed rate used was 100 kg ha^{-1} while row to row spacing was kept at 25 cm.

Seedlings were counted daily, from a tagged area of one meter length including 4 rows. Counting started with the beginning of emergence and was continued until emergence counts were constant in each plot. Emergence rate index (ERI) was calculated using a modified method described by Maguire (1962).

$$ERI = Xi/Yi + \dots\dots\dots + Xi{+}n/Yi{+}n.$$

Where.

Xi = Number of seedlings emerged for the ith day.
Yi = Number of days from the first seedling emergence.
n = Number of days

To better evaluate wheat stand establishment in rainfed environment, water requirements (consumptive use) at seedling stage were calculated. Crop coefficient (Kc) values were obtained and water-requirements were calculated, adopting procedures given by Doorenbos and Pruitt (1977). Soil moisture contents were determined according to Winkleaman *et al* (1986). Analysis of variance (ANOVA) was accomplished by using MSTAT computer package.

Results and Discussion

Wheat emergence. A combined analysis of cropping systems over two years was carried out. The combined analysis showed significant interaction between cropping systems and years, therefore, the means of emergence and emergence rate index are presented on individual year basis. Emergence count given in Table 1 revealed significant ($P<0.05$) differences among cropping systems. During 1992-93 wheat after fallow resulted in 179 seedlings m^{-2}. The number of wheat seedlings after mashbean, mungbean and cowpeas were non-significantly different from the fallow-wheat system.

The lowest seedling number was recorded in the millet-wheat system (80.3). Significantly less ($P<0.05$) number of seedlings than the fallow-wheat system, were observed in maize-wheat, sorghum-wheat, millet-wheat, sunflower-wheat and soybean-wheat. During 1993-94, wheat emergence was highest in fallow-wheat system (172 m^{-2}). The other systems which resulted in statistically comparable emergence count with fallow-wheat system were maize-wheat, mashbean-wheat, mungbean-wheat and cowpea-wheat. On the basis of wheat emergence, two distinct groups of cropping systems were observed. The first group included fallow-wheat, mashbean-wheat, mungbean-wheat and cowpea-wheat systems. The second group, contained maize-wheat, sorghum-wheat, millet-wheat, sunflower-wheat and soybean-wheat systems. Emergence count was higher in the first than the second. Legume-based cropping systms proved superior over non-legume based cropping systems regarding wheat emergence and were at par with fallow-wheat system. One exception was the soybean-wheat system which might have had higher moisture loss through evaporation from inter-row spacing. The soybean variety was an erect type and did not provide proper soil cover like other legume crops. Another exception was the maize-wheat system in 1993-94, which gave significantly higher ($P<0.05$) emergence than other non-legume cropping systems. During Kharif 1993, maize was harvested as fodder (due to damage by wild boar) at the peak of its water requirement stage, hence, it depleted less soil water (due to reduced life span) than the Kharif 1992 and its trash in the field provided mulch to reduce moisture loss.

Wheat emergence rate index. Emergence rate index was significantly higher ($P<0.05$) after cowpea-wheat, mashbean-wheat, fallow-wheat and mungbean-wheat than non-legume based cropping systems during 1992-93 (Table-2). Similarly, during 1993-94, ERI was significantly higher ($P<0.05$) in fallow-wheat, maize-wheat, mashbean-wheat, mungbean-wheat and cowpea-wheat than other systems (Table 2).

On the basis of ERI, the same two groups of cropping systems were observed as in the case of emergence count during both the seasons though ERI was low during 1993-94. In Rabi 1992-93 emergence was completed in a short period and wheat emergence rate index was higher than 1993-94. In Rabi 1993-94 wheat seedling establishment period (November-December) was drier than in 1992-93 (Table 3). During second dekad (ten day period) of November 1992, 34 mm of rain was received on the 19th of November (wheat sown on 10th November).

The perusal of Table 3 also shows that in the second dekad of November 1992, rainfall was higher than the requirements. Hence, there was better wheat stand establishment with ERI during 1992-93. Whereas, during 1993-94, there was 8.7 mm of rain on the 5th November (wheat sown on the 8th November) and after that no rainfall was received. However, potential evapotranspiration and water requirements remained higher at wheat establishment time during 1993-94 than 1992-

93 (Table 3). Therefore, emergence was poor and emergence rate index was low during 1993-94. This year poor wheat crop was established, particularly in sorghum-wheat, millet-wheat and soybean-wheat cropping systems even after rains, during first dekad of January.

Soil moisture contents. Variation in emergence and emergence rate of wheat in different systems was associated with initial soil moisture contents at the sowing time of wheat. The peering of the data given in Table 4 indicates that emergence, emergence rate index and soil moisture within that year correlate significantly. It is important to mention that the correlation of moisture contents between two years at sowing time of wheat was non-significant.

During 1992-93 significant ($P<0.05$) the highest residual soil moisture in the top 15 cm soil layer was found in the cowpea-wheat cropping system. Other systems with high soil moisture contents were fallow-wheat, mashbean-wheat and mungbean-wheat. Soil moisture contents were significantly ($P<0.05$) lower in soybean-wheat and non-legume based wheat cropping systems than legume and fallow system (Table 5). During 1993-94, highest soil moisture contents were found in mashbean-wheat and mungbean-wheat systems. Systems with non-significant different moisture contents were fallow-wheat and maize-wheat. Soil moisture contents were again low in non-legume and soybean based cropping systems.

More soil moisture was available in legume-based systems which may be associated with the fact that these legume crops, due to fast emergence, provided an early ground cover and

Table 1

Wheat emergence (m^{-2}) in different cropping systems

Cropping systems	1992-93	1993-94
Fallow-Wheat	179 a	172 a
Maize-Wheat	103 b	169 a
Sorghum-Wheat	107 b	117 bc
Millet-Wheat	80 b	89 c
Sunflower-Wheat	95 b	94 c
Mashbean-Wheat	191 a	165 a
Mungbean-Wheat	185 a	170 a
Cowpeas Wheat	179 a	145 a
Soybean-Wheat	97 b	102 c

Values followe by same letter within columns are not significantly different at 0.05 probability level.

Table 2

Wheat emergence rate index in different cropping systems

Cropping systems	1992-93	1993-94
Fallow-Wheat	91.8 b	48.9 a
Maize-Wheat	12.6 c	39.4 ab
Sorghum-Wheat	17.6 c	21.9 bc
Millet-Wheat	8.7 c	7.2 c
Sunflower-Wheat	15.2 c	7.7 c
Mashbean -Wheat	113.5 ab	38.9 ab
Mungbean-Wheat	83.9 b	45.9 a
Cowpeas Wheat	143.5 a	37.2 ab
Soybean-Wheat	17.2 c	12.4 c

Values followed by same letter within column are not significantly different at 0.05 probability level.

Table 3

Rainfall and water requirements of wheat during seedling establishment.

Month	Dakad	Rainfall (mm)	Potential evapotrans-piration	Crop coefficients (Kc)	Water requirements (mm)
November	1	0.0	24.4	0.20	4.3
92-93	2	35.0	17.1	0.20	3.4
	3	0.0	12.7	0.30	3.8
Decembe	1	0.0	12.4	0.30	3.7
92-93	2	8.0	10.3	0.30	3.1
	3	0.0	12.5	0.48	6.0
November	1	8.7	22.9	0.20	4.6
93-94	2	0.0	19.7	0.20	3.9
	3	0.0	16.3	0.30	4.9
December	1	0.0	15.2	0.30	4.6
93-94	2	0.0	12.7	0.30	3.8
	3	0.0	14.1	0.43	6.1

Table 4

Correlation between wheat emergence, emergence rate index and soil moisture contents

Emergence 1992-93					
Emergence 1993-94	0.796**				
ERI 1992-93	0.934**	0.631			
ERI 1993-94	0.842**	0.984**	0.697*		
Moisture 1992-93	0.876**	0.531	0.881**	0.589	
Moisture 1993-94	0.756*	0.881**	0.566	0.816**	0.546

* Significant at 5% level of probability ** Significant at 1% level of probability

also had short gowing period. As a result soil moisture loss due to evaporation was minimized and thus transpiration remained as a dominant process during growth cycle. Another advantage of those legumes may be their tap root system, which may have helped to absorb more water from the deeper layers of soil. Hence, these cropping systems provided enough initial residual soil moisture contents for wheat stablishment.

In consonance with our results, more soil moisture availablity after legume crops than non-legumes was also reported by others (Srivastva et al 1985; Badruddin and Meyer 1989). On the other hand, non-legum crops utilized much of the Kharif moisture due to their long life span. Water was also lost from soil surface due to more inter-row spacing through evaporation. Non-legume crops also utilized moisture from upper surface as well as from deeper layers of the soil due to their root system (Srivastva *et al* 1985; Cox and Jouiff 1987). Hence, ultimately less moisture was available after these crops for establishment of following wheat crop.

Among the legumes, soybean (variety NARC-II) was an exceptional crop which did not leave much soil moisture like other legume crops under study for establishment of following wheat crop. This may be due to the fact that it was an errect type variety, which did not dropped its leaves during final stages of its growth hence, its canopy did not help enough soil mulching. In a study (Papendic and Campbell 1974) observed significantly high moisture losses from a non-cropped surface than cropped surface and they believed that it was due to the mulching effect of having a crop on soil surface. Cox and Jolliff (1987) also reported that dryland soybean depleted 45% less soil moisture than sunflower but in the present study both were at par with each other in residual soil moisture.

The results have given clear understanding that under rainfed conditions wheat emergence and emergence rate are mainly function of the weather conditions and residual soil moisture in the seeding zone. The study also reveals that some legume crops can leave adequate soil moisture contents for subsequent wheat stand establishment similar to fallow system. The additional benefit of including these legume crops in a cropping system is increased profitability to the farmers of rainfed areas.

Table 5

Volumetric soil moisture contents (%) in the top 15 cm soil layer in different cropping systems

Cropping systems	1992-93	1993-94
Fallow-Wheat	11.6 b	13.2 abc
Maize-Wheat	7.1 e	13.2 abc
Sorghum-Wheat	8.2 d	9.2 d
Millet-Wheat	5.6 f	9.1 d
Sunflower-Wheat	9.8 c	10.9 cd
Mashbean-Wheat	12.5 b	14.9 a
Mungbean-Wheat	12.4 b	14.1 ab
Cowpea -Wheat	13.5 a	11.1 bcd
Soybean-Wheat	9.9 c	9.5 d

Values followed by same letter within column are not significantly different at 0.05 probability level.

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