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EFFECT OF SPATIAL ARRANGEMENT AND DENSITY ON WEED INFESTATION AND YIELD OF MAIZE (*ZEA MAYS* L.)

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Abstract

Field experiments were conducted during summer season 2012 and consequently repeated in 2013 to assess the efficacy of row and plant spacing on weed infestation and yield of maize crop. The experiments were carried out in Randomized Complete Block (RCB) design with split plot arrangements. Three row spacings i.e. 60, 75 and 90 cm were assigned to main plots while different plant spacings i.e. 10, 15, 20, 25 and 30 cm were allotted to subplots, respectively. The results showed that for both the year's narrow row and plant spacing effectively suppressed weeds while wider row and plant spacing resulted in higher weed density. The data showed that the maximum weed density (202.07 and 218.70 m^{-2}) was recorded in 90 cm row spacing in 2012 and 2013, respectively. However, among plant spacing highest weed density of 214.89 m^{-2} and 219.83 m^{-2} was recorded in 30 cm plant spacing during 2012 and 2013, respectively. The data regarding biological yield showed maximum biological yield in 60 cm row spacing while among plant spacing the highest biological yield was resulted in narrow plant spacing of 10 cm during both years. Furthermore, highest grain yield of 4928.9 kg ha^{-1} in 2012 and 5063.9 kg ha^{-1} in 2013 was recorded in 75 cm row spacing while lowest grain yield of 3026 kg ha^{-1} in 2012 and 3989 kg ha^{-1} in 2013 was observed for 90 cm row spacing. Among plant spacing highest grain yield of 4474.8 kg ha^{-1} and 5228.5 kg $ha^{-1}$was recorded in 15 cm plant spacing whereas lowest grain yield of 3554 kg ha^{-1} and 4010.6 kg ha^{-1} was observed for 30 cm row spacing in 2012 and 2013, respectively. The regression analysis also showed highest grain yield form 15-20 cm plant spacing during both years. Similarly the correlation data showed that with increase in weed density the grain yield decreases accordingly. The two years of research showed that narrow spacing (15-20 x 75 cm) enhanced the competitive ability of maize crop and suppressed weed growth.

Key words: Maize, Plant spacing, Row spacing, Weed and yield.

Introduction

Maize is a crop of 3-4 months duration, benefits the farmers more as compared to other crops, thus occupies an important place among the cropping pattern of Pakistan (Anon., 2013). The available maize verities are mostly high yielding but still farmers of Pakistan cannot get that much yield because of many reasons, one major reason is weeds. Weeds affect the main crop with many ways, for example they not only reduced the quantity but also effect grain quality etc. (Maqsood *et al*., 1999). During the first thirty days the maize crop is very susceptible to the weed competition and may cause severe yield losses due to its slow growth (Kayode & Ademiluyi, 2004; Young *et al*., 1996 and Khan *et al*., 2009). In many papers the losses were reported from twenty to forty percent in the initial phase of growth (Anonymous, 2005). However, if they were not controlled then it could range to seventy percent (Ford & Pleasant, 1994).

The removal of weeds with manual implements does not seems economical anymore due to it high cost of labour (Cheema *et al*., 2003). In short terms herbicides use could be economical but in long runs it is not good due to its negative impact on environment and health (Gul *et al*., 2009). Among all environment friendly and economical techniques, proper row and plant spacing is one of the best option for better weed management and yield of maize crop. Maize is very susceptible to spatial arrangement in comparison to its other family members (Almeida & Sangoi, 1996). Thus it should be better exploited for its proper row and plant spacing in fields having high weed infestation to get high yield (Sangoi, 2000; Hassan, 2000; Sharratt & McWilliams, 2005 and Singh & Singh, 2006).

Materials and Methods

A research project was conducted in Malakandher farm of The University of Agriculture Peshawar-Pakistan in the year 2012 and was repeated in 2013 on the same field to confirm the results. The RCB design having split-plot arrangements with 03 replications was used in both the experiments.

A row spacing of (60, 75 and 90 cm) was used in main plot and plant spacing of (10, 15, 20, 25 and 30 cm) was used in subplots. Azam variety of *Zea mays* L. and a fertilizer doses of N= 150 kg and P=90 kg ha^{-1} was used. Insecticide and irrigation was done as required. Analysis was done on STATISTICS Software.

Results and Discussion

Weed density (m^{-2}): The weed density and their interactions were found significant in year 2012 and 2013. The mean data of row spacing in the growing season 2012 illustrated maximum weed density (202.07 m^{-2}) in wider row spacing of 90 cm and minimum weed density (145.20 m^{-2}) was noticed in 60 cm row spacing (Table 1). Similarly the plant spacing mean data revealed that the lowest weed density (131.11 m^{-2}) was resulted in narrow plant spacing i.e. 10 cm which is followed by 15 cm plant spacing (152.67 m^{-2}) whereas the highest weed density (214.89 m^{-2}) was recorded in 30 cm wider plant spacing. The interaction data showed that as the row and plant spacing increased, the weed density per meter square also increased. The results showed that maximum weed density (237.33) was observed in wider row and plant spacing of 90 X 30 cm while the minimum (101.67 m^{-2}) was noticed in narrow row and plant spacing of 60 X 10 cm, respectively.

The mean data of row spacing in year 2013 also revealed that maximum weed density (218.70 m^{-2}) was noticed in wider row spacing of 90 cm while the minimum weed density (168.19 m^{-2}) was observed in 60 cm row spacing (Table 1). Furthermore, the data regarding plant spacing showed that the lowest weed density (161.42 m^{-2}) was due to in narrow plant spacing i.e. 10 cm as the highest weed density (219.83 m^{-2}) was recorded in 30 cm wider plant spacing. The interaction data showed that maximum weed density (243.67) was recorded in wider row and plant spacing of 90 X 30 cm while minimum (132.93 m^{-2}) was observed for narrow row and plant spacing of 60 X 10 cm respectively.

Table 1. Weed density (m^{-2}) as influenced by row and plant spacing in 2012 and 2013.

	Weed density (m^{-2})	
	Year	
	2012	**2013**
Row spacing (R) (main plot)		
60 cm (R1)	145.20 c	168.19 c
75 cm (R2)	174.60 b	188.97 b
90 cm (R3)	202.07 a	218.70 a
LSD $_{(0.05)}$	9.33	11.09
Plant spacing (P) (sub-plot)		
10 cm (P1)	131.11 e	161.42 e
15 cm (P2)	152.67d	178.61 d
20 cm (P3)	171.89 c	195.67 c
25 cm (P4)	199.22 b	204.22 b
30 cm (P5)	214.89 a	219.83 a
LSD $_{(0.05)}$	6.11	5.2
Interaction (R x P)		
(R1 x P1)	101.67 j	132.93 h
(R1 x P2)	124.33 i	155.50 g
(R1 x P3)	141.33 gh	174.50 ef
(R1 x P4)	174.67 de	186.00 de
(R1 x P5)	184.00 d	192.00 d
(R2 x P1)	129.33 hi	163.67 fg
(R2 x P2)	150.67 fg	171.83 f
(R2 x P3)	167.67 e	189.00 d
(R2 x P4)	202.00 c	196.50 cd
(R2 x P5)	223.33 b	223.83 b
(R3 x P1)	162.33 ef	187.67 de
(R3 x P2)	183.00 d	208.50 c
(R3 x P3)	206.67 c	223.50 b
(R3 x P4)	221.00 b	230.17 b
(R3 x P5)	237.33 a	243.67 a
LSD $_{(0.05)}$	10.58	9.01
Year mean	173.96 b	191.95 a

Regression analysis revealed that weed density was increased with increasing plant spacing in all row spacing (Figs. 1 & 2). The overall response was quadratic during both years. The present findings showed that higher weed density in both row and plant spacing might be due to the sufficient availability of space, moisture, nutrients and other growth requirements. Likewise the lower weed density in narrow row and plant spacing was due to less space and smothering effect of maize crop on weeds due to which weed can't grow efficiently. Maqbool *et al*., 2006 reported that wider row and plant spacing resulted in higher weed density as compared to narrow spacing (Tharp & Kells. 2001; Begna *et al*., 2001; Ottman & Welch, 1999; Andrade *et al*., 2002 and Forcella *et al*., 1992).

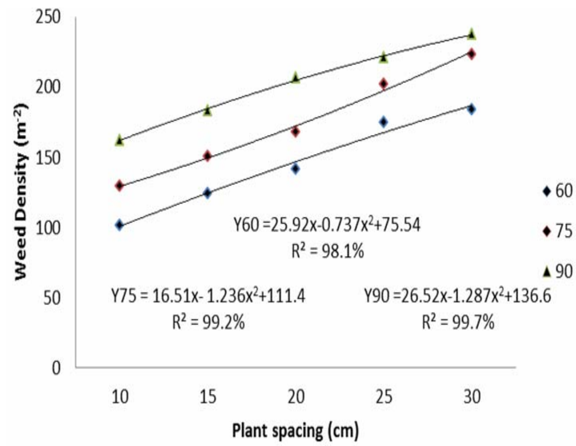

Fig. 1. Interactive effect of row and plant spacing on weed density (m^{-2}) for 2012.

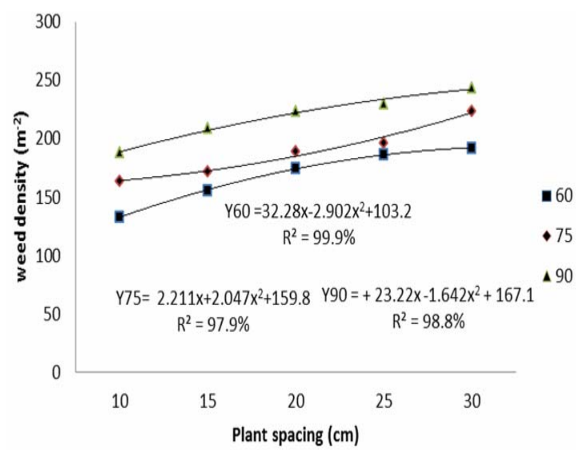

Fig. 2. Interactive effect of row and plant spacing on weed density (m^{-2}) for 2013.

Biological yield (kg ha^{-1}): The biological yield of maize and their interaction was also recorded significant during both years. The row spacing mean data of 2012 revealed that highest biological yield (9285.5 kg ha^{-1}) was resulted in narrow row spacing of 60 cm while the lowest biological yield (7501.5 kg ha^{-1}) was noticed in 90 cm (Table 2). The plant spacing mean data showed that highest biological yield (9059.7 kg ha^{-1}) was recorded in 10 cm while the minimum biological yield (7987.3 kg ha^{-1}) was recorded in 30 cm plant spacing. The interaction data of row and plant spacing revealed that highest biological yield was calculated in narrow spacing while the lowest was computed in wider spacing. The data showed that maximum biological yield (9848.7 kg ha^{-1}) was recorded in 60 X 10 cm while the lowest (7125.7 kg ha^{-1}) was noticed in 90 X 30.

The observed data for 2013 showed that for row spacing highest biological yield (9683 kg ha^{-1}) was resulted in narrow row spacing of 60 cm while the lowest biological yield (6618.09 kg ha^{-1}) was noticed in 90 cm (Table 2).

The regression analysis showed that as plant spacing increases the biological yield decreases accordingly in all row spacing during both years (Figs. 3 & 4). The Correlation data in table 3 showed a significant effect on weed density by plant spacing and row spacing in 2012 and 2013. The Correlation showed that as weed density increased the biological yield of maize decreased accordingly in both row and plant spacings during both years (Moaveni *et al.*, 2011; Toler *et al*., 1999 and Hashemi *et al*. (2005).

Table 2. Biological yield (kg ha^{-1}) of maize as influenced by row and plant spacing in 2012-2013.

	Year	
	2012	2013
Row spacing (R) (main plot)		
60 cm (R1)	9285.5 a	9683.5 a
75 cm (R2)	8676.3 b	8298.4 b
90 cm (R3)	7501.5 c	6618.0 c
LSD $_{(0.05)}$	160.58	322.99
Plant spacing (P) (sub-plot)		
10 cm (P1)	9059.7 a	8473.5 a
15 cm (P2)	8449.6 c	8305.7 b
20 cm (P3)	8676.4 b	8258.9 b
25 cm (P4)	8265.9 d	8055.1 c
30 cm (P5)	7987.3 e	7909.2 d
LSD $_{(0.05)}$	92.57	69.36
Interaction (R x P)		
(R1 x P1)	9848.7 a	9887.8 a
(R1 x P2)	9385.7 c	9757.0 b
(R1 x P3)	9643.0 b	9734.0 b
(R1 x P4)	8932.0 d	9570.8 c
(R1 x P5)	8618.0 e	9467.7 c
(R2 x P1)	9318.3 c	8604.3 d
(R2 x P2)	8538.7 e	8461.2 e
(R2 x P3)	8848.7 d	8391.0 e
(R2 x P4)	8457.7 e	8166.7 f
(R2 x P5)	8218.3 f	7869.0 g
(R3 x P1)	8012.0 f	6925.7 h
(R3 x P2)	7424.3 g	6698.8 I
(R3 x P3)	7537.7 g	6651.8 i
(R3 x P4)	7408.0 g	6427.7 j
(R3 x P5)	7125.7 h	6391.0 j
LSD $_{(0.05)}$	160.64	120.14
Year Mean	8487.8 a	8200.5 b

Grain yield (kg ha^{-1}): The analysis of the data showed significant effect of row and plant spacing on grain yield of maize while their interaction was also significant. The analysis of data showed significant effect for year means (Table 4). The row spacing mean data revealed that highest grain yield (4928.1 kg ha^{-1}) was recorded in 75 cm followed by 60 cm with the grain yield of 4183.5 kg ha^{-1} while the lowest grain yield (3026.7 kg ha^{-1}) was noticed in 90 cm row spacing.

The row spacing mean data in table 4 for 2013 in the same way the plant spacing mean data showed that maximum grain yield (5228.5 kg ha^{-1}) was resulted in 15 cm which is followed by 20 cm (4940.7 kg ha^{-1}) while the lowest grain yield (4010.6 kg ha^{-1}) was recorded in 30 cm plant spacing. The interaction data of both row and plant spacing revealed that highest yield (5744.8 kg ha^{-1}) was obtained in 75 X 15 cm while the lowest yield (3448.5 kg ha^{-1}) was recorded in 90 X 30 cm spacing.

Table 3. Correlation of weed density vs. biological yield as affected by different row and plant spacing (cm) for 2012 and 2013.

		Biological yield	p-value
Year 2012			
Row spacing	Weed density	0.5981	0.0001
Plant spacing	Weed density	0.7801	0.0000
Year 2013			
Row spacing	Weed density	0.6941	0.0000
Plant spacing	Weed density	0.6780	0.0000

*Correlation is significant at 0.05 level

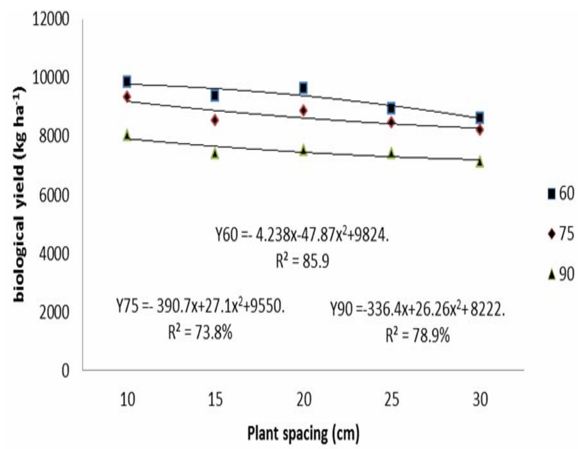

Fig. 3. Interactive effect of row and plant spacing on biological yield (kg ha^{-1}) of maize for 2012.

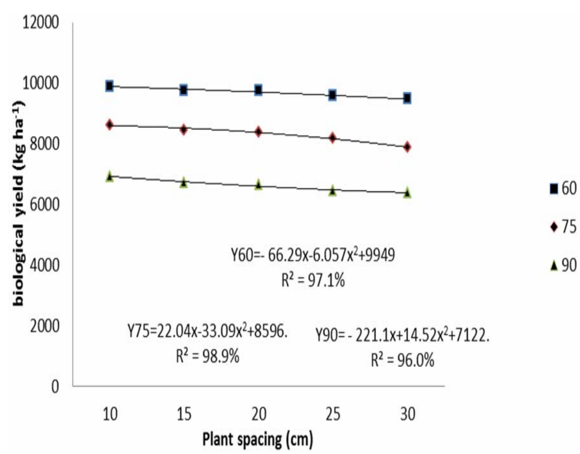

Fig. 4. Interactive effect of row and plant spacing on biological yield (kg ha^{-1}) of maize for 2013.

Table 4. Grain yield (kg ha^{-1}) of maize as influenced by row and plant spacing in 2012-13.

	Year	
	2012	**2013**
Row spacing (R) (main plot)		
60 cm (R1)	4183.5 b	4724.3 b
75 cm (R2)	4928.1 a	5063.9 a
90 cm (R3)	3026.7 c	3989.0 c
LSD $_{(0.05)}$	245.66	116.54
Plant spacing (P) (sub-plot)		
10 cm (P1)	4135.8 b	4522.9 c
15 cm (P2)	4474.8 a	5228.5 a
20 cm (P3)	4231.3 b	4940.7 b
25 cm (P4)	3834.7 c	4259.3 d
30 cm (P5)	3554.0 d	4010.6 e
LSD $_{(0.05)}$	207.4	77.84
Interaction (R x P)		
(R1 x P1)	3742.7 g	4596.0 d
(R1 x P2)	4700.3 cd	5363.5 b
(R1 x P3)	4577.3 cde	5162.3 c
(R1 x P4)	4145.7 f	4319.0 ef
(R1 x P5)	3751.7 g	4180.5 g
(R2 x P1)	5655.3 a	5029.2 c
(R2 x P2)	4967.3 bc	5744.8 a
(R2 x P3)	5214.0 b	5428.2 b
(R2 x P4)	4562.0 de	4714.5 d
(R2 x P5)	4241.7 ef	4402.7 e
(R3 x P1)	3009.3 hi	3943.7 h
(R3 x P2)	3510.0 g	4577.2 d
(R3 x P3)	3149.3 h	4231.5 fg
(R3 x P4)	2796.3 hi	3744.3 I
(R3 x P5)	2668.7 i	3448.5 j
LSD $_{(0.05)}$	359.22	134.83
Year mean	4046.1 b	4592.4 a

The overall results in table 4 demonstrated that proper row and plant spacing are necessary to obtain higher grain yield. The lower grain yield in wider row and plant spacing was might be due to less number of plants in the given area which resulted less number of cobs and grains. The maximum grain yield in 15 and 20 cm plant spacing was might be due to maximum plants per given area and proper distribution of growth resources which resulted higher grain yield and other yield components. Similar trend was also obtained by Porter *et al*. (1997). In other study Shapiro & Wortmann (2006) concluded that by decreasing the row spacing there 4% increase in grain yield of maize was increased. The present results are in line with the previous results reported by Rehman *et al*. (2008) who stated that maximum grain yield was obtained from 75 X 20 cm spacing.

The regression analysis revealed that highest grain yield (kg ha^{-1}) was obtained from 15-20 cm plant spacing (Figs. 5 & 6). The R^2 values of different row spacing 60, 75 and 90 cm were 86, 95 and 19%, respectively. The correlation data in table 5 showed a negative correlation between weed density and grain yield. Each increment in plant spacing decrease the grain yield. Similarly the grain yield of maize also minimized due to maximization of weed density (Ramezani *et al*., 2011; Cox & Cherney (2001) and Sangoi, 2000)).

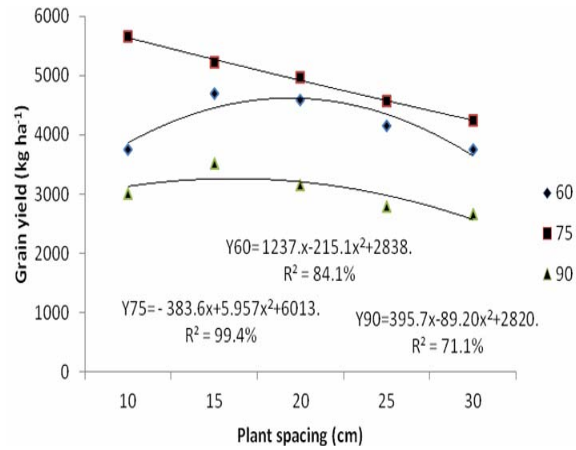

Fig. 5. Interactive effect of row and plant spacing for 2012 on grain yield (kg ha^{-1}) of maize for 2012.

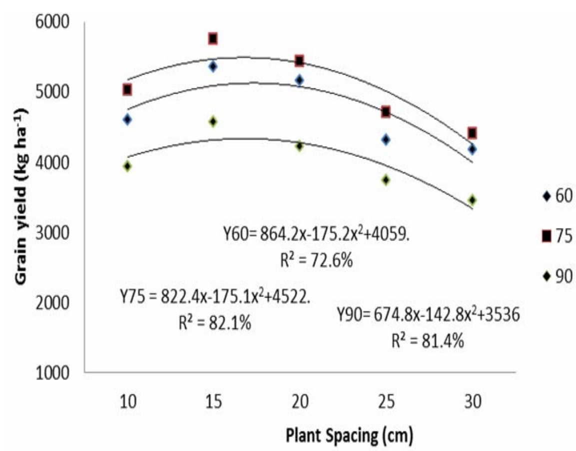

Fig. 6. Interactive effect of row and plant spacing for 2012 on grain yield (kg ha^{-1}) of maize for 2013.

Table 5. Correlation of weed density vs. grain yield as affected by different row and plant spacing (cm) for 2012 and 2013.

		Grain yield	p-value
Year 2012			
Row spacing	Weed density	-0.5261	0.0001
Plant spacing	Weed density	-0.5261	0.0585
Year 2013			
Row spacing	Weed density	-0.4706	0.0011
Plant spacing	Weed density	-0.4422	0.0024

*Correlation is significant at 0.05 level

Conclusion and Recommendations

From the foregoing results it was concluded that,

- Both row and plant spacing had significant effect on weed infestation and yield parameters.
- Our results revealed that row spacing of 75 cm and plant spacing of 15 and 20 cm resulted better yield and satisfactory suppression of weeds.
- Narrow spacing increased the fodder production but lowered the overall yield due to the intraspecific competition among the maize plants.
- Wider spacing increases the chance to weeds to infest the crop and lowered the crop yield.

Hence it was recommended from the above conclusions that proper row and plant spacing are necessary to obtain higher yield of maize crop. As the population is increasing day by day and the food requirement is hence increased. So being important cereal crop better eco-friendly techniques are to be adapted to obtain maximum yield and to get rid of weed menace. Farmers are advised to grow maize on 75 cm row spacing while keeping the plant spacing of 15 and 20 cm to obtain maximum yield. The farmers who are interested in maize for fodder purpose are suggested to grow maize on 60 cm row spacing and 10 cm plant spacing.

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