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COMBINED EFFECT OF NITROGEN FERTILIZERS AND HERBICIDES UPON MAIZE PRODUCTION IN PESHAWAR

N. Khan, N. W. Khan, S. A. Khan, M. A. Khan and K. B. Marwat

Agricultural University Peshawar-25120, Pakistan
Corresponding author: nk_khandr@yahoo.com

ABSTRACT

Maize is an excellent source of energy in human diet and animal rations. To find out the cumulative effect of nitrogen (N) and herbicidal weed control upon the various growth parameters of maize, an experiment was conducted in summer season of 2006 at the Malakandher Research Farm, Agricultural, University Peshawar. The experiment was performed using randomized complete block design having split plot arrangements. All the treatments were replicated four times. The treatments consisting 3 N fertilizer (Urea) rates (i.e. 80, 120 and 160 kg ha^{-1}) and 3 herbicides (Atrazine @ 1.00 kg a.i ha^{-1}, Stomp @ 0.75 kg a.i ha^{-1} and 2,4-D @ 0.80 kg a.i ha^{-1}) and a weedy check was kept along each treatment for comparison. The main-plots having the N rates while the sub-plots having the herbicides. The N fertilizer was applied in two split doses (i.e. the first dose at the first irrigation after seed germination and the second dose a week before the silking). The pre-emergent herbicides (Stomp and Atrazine) were applied during sowing and the post emergent herbicide (2,4-D) was applied after 25 days of sowing. Fresh weed biomass was lower (34.0 g m^{-2}) in the atrazine treated plots than in the weedy check plots (54.2g m^{-2}). The maximum days to 50% tasseling (61.6) taken by the plants fertilized with 160 kg ha^{-1} N and plants which received 80 and 120 kg ha^{-1} N had spent statistically similar days to 50% tasseling**.** The effect of herbicides and their interaction with N rates was non-significant. The maximum 500 kernel weight (92.8 and 90.2 g) was achieved in the plots which received 160 and 120 kg ha^{-1} N, respectively. The heaviest 500 kernel weight (91.5 g) was noted in Atrazine treated plots and lightest 500 kernel weight (85.8 g) was found in weedy check plots. The largest biological yield (3.1 t ha^{-1}) was recorded for 160 kg ha^{-1}. The maximum biological yield (3.2 t ha^{-1}) was found for Atrazine while the lowest (2.4 t ha^{-1}) for weedy check. The overall effect of 160 kg ha^{-1} N application rate and Atrazine was found to be highly desirable for weed control and for promoting yield and yield components of maize.

Key words: Nitrogen rates, herbicides, weed control, maize and yield components, fodder.

INTRODUCTION

Maize is a member of Poaceae family having annual life cycle. Maize possesses a straight stem (composed of nodes and internodes) and bearing narrow broader leaves. Its male inflorescence at the top of the plant is called tassel and its female inflorescence on the middle of stalk is called ear. Maize is grown in many countries as an important food grain crop. It is the third most important crop after wheat and rice in Pakistan. Maize can be used as food for people, livestock feed, poultry feed and also producing raw materials for a number of industries (Bibi *et al*., 2010). In Pakistan, maize is grown both in irrigated and rainfed areas and Punjab, Sindh and Khyber Pakhtunkhwa (KPK) are the main growing provinces of maize (Irshad *et al*., 2002). In 2008-2009, maize was sown on 981.8 thousand hectares area producing 2797.0 thousand tons grains with an average grain yield by 2849 kg ha^{-1} and in KPK, maize was grown on 509.5 thousand hectares which yielded a total of 957.9 tons grains and average grain yield by 1880 kg ha^{-1} (MINFAL, 2008-2009).

Many factors like shortage or expensiveness of quality seed, insects and pathogenic organisms and costly agricultural inputs can all decrease the yield of maize, but the infestation of various weeds is the most important factor involved in the crop yield reduction. A number of weeds have been noted infesting maize crop in KPK and decreasing the crop yield by In maize the monetary losses on annual basis are reported to be greater than Rs.6.3 billion at national level and greater than Rs.3.2 billion at provincial (KPK) level (Hassan and Marwat, 2001). The yield losses may increase up to 35-70% in case the weeds are left freely to compete with the crop for growth resources and not controlled in time appropriately (Ford and Pleasant, 1994; Teasdale, 1995). Many weeds [e.g. barnyard grass (*Echinocloa crus-galli* (L.) Beauv.), purple nutsedge (*Cyperus rotundus* L.), Johnson grass (*Sorghum helepense* L.), Bermuda grass (*Cynodon dactylon* (L.) Pers.), field bind weed (*Convolvulus arvensis* L.), false amaranth (*Digera muricata* (L.) Mart.) and common purslane (*Portulaca olereacea* L.) etc. infesting maize and causing significant yield losses to the crop in KPK (Ullah *et al*., 2008; Hassan *et al*., 2010). Weeds infestation above the critical threshold point can greatly decrease production and quality of crops (Cussans, 1968). Weeds compete with the maize plants for growth resources such as the natural light, water and nutrients especially the nitrogen (N) which possesses a vital function in the plants growth (Sinclair, 1995).

Various management methods for weeds control may be useful for maize crop including cultural weed control (Begna *et al*., 2001), the cultivation of competitive varieties (Hassan *et al*., 2010), and manual weed control (Abouziena *et al*., 2008). But these methods may not be accessible and economical always due to a number of demerits like unavailability and higher prices of the hybrid varieties of maize, dependency of manual weeding on weather conditions as well as time consuming on larger areas (Chaudhry, 1994). Therefore, other management methods of weeds are required to be used for maize crop which are more effective in controlling the weeds, feasible under local conditions within a short period of time on larger fields, give quicker results and minimizing production losses of maize crop. One such management method of weeds in maize could be the integration of desired N rates to establish healthy and rapidly growing vigorous crop, and the application of suitable herbicides which can effectively kill the weeds in time in maize crop.

Most of the Pakistani soils contain lower N contents (Rashid, 1994) and a considerable part of the applied N is said to be volatized into the atmosphere as well as lost downward into the soil through leaching (Zhang *et al*., 2009) which can reduce the growth and yield of maize plants (NFDC-FAO. 2006). In such a scenario, application of adequate higher N application rates were found useful in promoting growth and in getting higher yields of maize in many research studies (e.g. Muchow, 1988; Rajcan and Swanton, 2001; Abbas *et al*., 2003; Rozas *et al*., 2008) as N is required by crop plants in sufficient amounts for their healthy and vigorous growth, and for achieving higher yields (Torbert *et al*., 2001). Thus knowing an adequate N application rate might also be useful in raising a more aggressive and competitive maize crop against the weeds and useful in achieving higher yields. In addition, the effectiveness of herbicides for controlling weeds and harvesting higher yields in maize crop has been documented in many research articles (Cavero *et al*., 2002; Ali *et al*., 2003; Ullah *et al*., 2008; Hassan *et al*., 2010), however, this weed control method was given little favor in Pakistan (Shah, 1998). Thus, in light of this information, a research study was undertaken to evaluate the effectiveness of N fertilizer (at three application rates) and three herbicides at their recommended application rates on weed control and maize production.

MATERIALS AND METHODS

An experiment was carried out at Malakander Research Farm, KPK Agricultural University, Peshawar (71° E and 34° N) during summer in 2006. The region has got a sub-tropical climate receiving mean annual precipitation of 365 mm but the mean summer rainfall is comparatively low to the mean winter rainfall. This region having the mean maximum and minimum temperature by 40 and 4^{o}C, respectively. The experimental design used was Randomized Complete Block design and having split plot arrangements. The N (in form of Urea) was applied at 3 rates (80, 120 and 160 kg ha^{-1}) and kept in the main plots, the 3 herbicides [Atrazine 330 EC @ 1.00 kg a.i ha^{-1}, Stomp 38 SC @ 0.75 kg a.i ha^{-1} and 2,4-D 72 (ester) @ 0.80 kg a.i ha^{-1}, Dow Agro Sciences ltd.], applied at their recommended rates were kept in sub-plots. A weedy check was maintained with each treatment in the sub-plots for comparison. All sub-plots were measuring 3 m x 5 m in size and each sub-plot containing 4 rows with 75 cm distance between each row. All the treatments applied were replicated 4 times. Using a cultivator, the experimental field was appropriately ploughed thrice followed by appropriate planking so as to build fine seed beds to aid in seed germination. The Azam maize variety seed at the rate of 40 kg ha^{-1} (recommended seeding rate) was seeded through hand pulling drill method. The experiment was properly monitored and irrigated whenever water was needed. The experiment was run for 96 days period.

The basal dose of 70 kg P_20_5 ha^{-1} was applied in the form of Single Super Phosphate during the sowing time of the trial in all experimental plots. The N rates were hand broad-casted inside all the nominated plots uniformly at two occasions in split doses. The 1st dose was applied 10-days after seed germination while the 2nd dose was applied 45-days after seed germination. Prior to application, all herbicides were measured and diluted in clean water properly one by one, and sprayed upon each respective nominated plots using a back-pack sprayer The herbicides treatments (Stomp 330 EC and Atrazine 38 SC) both as pre-emergence were sprayed through back-pack sprayer and incorporated with the soil during the crop seeding time while 2,4-D 72 (ester) as post emergence was applied using back-pack sprayer after 25-days of seed germination. The experimental treatments description is as under:

Nitrogen rates (in main-plots)

N1= 80 kg ha^{-1}; **N2**= 120 kg ha^{-1}; **N3**= 160 kg ha^{-1}

Herbicides and the weedy check (in sub-plots)

T1= Atrazine 38 SC (at 1.00 kg a.i ha^{-1}) as pre-emergent; **T2**= Stomp 330 EC (at 0.75 kg a.i ha^{-1}) as pre-emergent; **T3**= 2,4-D 72 (ester) (at 0.80 kg a.i ha^{-1}) as post emergent; **T4**= Weedy check

Parameters recorded and procedures:

Fresh weed biomass: This was measured in all the experimental plots after 30 days of sowing of the crop by randomly throwing a quadrate (0.25 m^{2} in size) three times inside each replicated plot, all the weeds occurring inside the quadrates were cut using a pair of manual shears their fresh biomass (g) was measured using a spring balance. The data was consequently converted on m^{-2} basis.

***Days to 50% tasseling*:** This was performed by randomly selecting 10 maize plants in all of the replicated plots at the growth stage of the plants when >50% plants had developed their tassels.

***Days to 50% plants silking*:** This was recorded on 10 maize plants randomly selected from all the replicated plots when >50% of maize plants had developed their silks.

***500 kernels weight*:** This was done by selecting randomly 500 kernels from the threshed kernels of all the replicated experimental plots and then weighed using an electronic balance in (g).

***Biological yield*:** To record biological yield of maize, the two central rows in all of the replicated experimental plots were harvested close to the soil level, bundled separately for each treatment, dried under sun light for 15 days and weighed using a spring balance to record their biological yield (kg) and subsequently converted to t ha^{-1}.

Statistical Analysis of the data: Using analysis of variance (ANOVA) technique, all the recorded parameters were analyzed by operating MSTATC statistical software. To identify significance of differences between the data means, the LSD of Steel and Torrie (1980) was applied.

RESULTS AND DISCUSSION

The fresh weed biomass: After 25 days of sowing maize crop, weeds were visually seen and identified. A total of 7 major weeds both grassy and broadleaf were noted infesting the maize crop. The grassy weeds seen including barnyard grass (*Echinocloa crus-galli* (L.) Beauv.), Johnson grass (*Sorghum halepense* L.), burmuda grass [*Cynodon dactylon* (L.) Pers.] and the broadleaf weeds found including false amaranth (*Digera muricata* (L.) Mart.), common purslane (*Portulaca oleracea* L.) and field bindweed (*Convolvulus arvensis* L.). In addition, one sedge [i.e. purple nutsedge; *Cyperus rotundus* L.] was also found infesting the maize crop during the trial.

Visual observation had confirmed that most of the weeds were effectively controlled using the herbicides, however, purple nutsedge was found to be not completely controlled by any of the herbicides used. The statistical analysis of the data recorded on the weeds fresh biomass revealed that the herbicides applied for weed control in maize had significantly decreased the weeds fresh biomass while the effect of the N rates was seen to be non-significant (P<0.05; Table 1).

The interaction of N rates and herbicides was also noted to be non-significant upon the fresh weeds biomass (P<0.05; Table 2). The least fresh weed biomass (34.0 g m^{-2}) was recorded in plots that were treated with Atrazine 38 SC followed by plots that were sprayed with Stomp 330 EC and 2,4-D (ester) where 41.2 and 45.5 g m^{-2} fresh weed biomass, respectively, was found (P<0.05; Table 2). The maximum fresh weed biomass (54.2 g m^{-2}) was recorded in weedy check plots (Table 2). All of the three N rates have shown statistically similar fresh weeds biomass (Table 2). These results showed that the use of herbicides have effectively killed the weeds and did not them to compete with the crop plants. Several researchers have found similar results (Nadeem *et al*., 1999; Saini and Angiras, 2000; Jacob, 2003; Hassan *et al*., 2010) all of them have observed lower fresh weed biomass in maize crop with the application of herbicides such as Dual gold 960 EC and Primextra 500 FW (both being pre-emergence selective herbicides).

The days to 50 % tasseling: Analysis of the data had indicated the N rates had a significant effect on the days to 50% tasseling of maize while the applied herbicides and their interaction with the N rates showed no effect on the days to 50% tasseling (P<0.05; Table 2). The highest number of days (61.6) had taken by the maize plants whose growth was supplemented with the highest N rate (160 kg N ha^{-1}) while the minimum number of days (60.2) were taken by those plants which were fertilized with the lowest rate of N (80 kg N ha^{-1}; Table 2). This indicates that high rates of N fertilization had decreased the maize plants early senesces chances and increased its growth duration due to better development followed by consequent higher achievement of high dry matter which possibly aided in the competitiveness of maize plants over the weeds. Our results are in line with those reported by Abbas *et al*. (2003) and Hussein *et al*. (2007) who reported significant increase in various growth parameters of maize when supplemented with higher rates of N fertilizer.

The days to 50 % silking: Statistical analysis of the data revealed that the N rates, herbicides and their interaction did not significantly affect the days to 50% silking of the maize crop (P<0.05; Table 1 and 2). However, as overall, maximum days (68.1) to 50% silking were spent by the plants which were fertilized with160 kg ha^{-1} N rate. For herbicides, the longest time (68.0 days) to 50% silking (Table 2) was taken by plants treated with Atrazine for weed control while the shortest time (67.4 days) was taken by plants treated with 2,4-D for weed control. Their interaction had the highest number of days (68.8 days) for Atrazine x 160 kg ha^{-1} N rate and the lowest number of days (66.3) for 2,4-D x 120 kg ha^{-1} N rate (Table 2). These results showed that time to silking development

Table 1 The mean squares for germination (%), fresh weed biomass (g m^{-2}), days to 50% tasseling and silking, 500 kernel weight and biological yield (t ha^{-1}) of maize as affected by the three nitrogen rates, pre and post emergent herbicides and their interaction.

Source of variation	d.f	Mean Squares				
		Fresh weed biomass (g m^{-2})	Days to 50% tasseling	Days to 50% silking	500 kernel weight (g)	Biological yield (t ha^{-1})
Replications	3	29.866	0.410	1.056	13.167	0.036
Nitrogen rates	2	10.145^{NS}	10.083*	3.083 ^{NS}	196.896*	0.974*
Error	6	4.923	0.556	3.306	9.646	0.053
Herbicides	3	856.578*	0.354 ^{NS}	0.722 ^{NS}	80.944 ^{NS}	1.386*
Interaction	6	22.999 ^{NS}	0.417 ^{NS}	2.639 ^{NS}	17.090 ^{NS}	0.034^{NS}
Error	27	6.304	0.322	2.426	46.560	0.103
CV (%)	-	5.73	0.94	2.30	7.62	17.04

*= Significant at P<0.05 NS= Non-significant

Table 2 The weed fresh biomass (g m^{-2}), days to 50% tasselling, days to 50% silking, 500 kernel weight (g) and biological yields (t ha^{-1}) of maize as affected by the different nitrogen rates used and the two pre-emergent herbicides and one post emergent herbicides applied and by their interaction.

Herbicides applied	Nitrogen rates used			Means for herbicides
	80 kg ha^{-1}	120 kg ha^{-1}	160 kg ha^{-1}	
		Weed fresh biomass (g m^2)		
Stomp	40.8	40.1	42.7	41.2c
Atrazine	33.7	56.2	33.3	34.0d
2,4-D	44.8	42.6	49.9	45.5b
Weedy Check	53.4	56.2	52.9	54.2a
Means for N rates	43.2	43.5	44.9	-
LSD (at P<0.05) for the herbicidal treatments= 3.262				
		Days to 50% tasselling of maize		
Stomp	60.2	60.3	61.0	60.5
Atrazine	60.0	60.0	61.5	60.5
2,4-D	60.0	60.5	62.0	60.8
Weedy Check	60.5	60.0	61.6	60.7
Means for N rates	60.1b	60.2b	61.6a	-
LSD (at P<0.05) for the N rates used = 1.134				
		50% silking of maize		
Stomp	66.5	68.4	68.3	67.7
Atrazine	68.0	67.3	68.8	68.0
2,4-D	68.3	66.2	67.7	67.4
Weedy Check	67.6	67.0	67.6	67.6
Means for N rates	67.4	67.3	68.1	-
		500 kernel weight (g) of maize		
Stomp	89.3	89.0	93.0	90.4
Atrazine	88.0	93.5	93.0	91.5
2,4-D	84.5	92.0	95.5	90.7
Weedy Check	81.5	86.3	89.5	85.8
Means for N rates	85.2b	90.2ab	92.8a	-
LSD (at P< 0.05) for the N rates = 4.725				
		Biological yields (t ha^{-1}) of maize		
Stomp	2.8	3.2	3.3	3.1a
Atrazine	2.7	3.1	3.4	3.2a
2,4-D	2.7	3.1	3.2	3.0a
Weedy Check	2.2	2.5	2.5	2.4b
Means for N rates	2.6b	3.0ab	3.1a	-

LSD (at P<0.05) for the N rates = 0.3502 and LSD (at P<0.05) for the herbicides = 0.4170.

may be associated to the inherent character of the maize variety "Azam" used in this trial as has been described in earlier study (Rahman *et al*., 2007). In addition, Subhan *et al*. (2007) have also reported similar results for maize crop.

The 500 kernel weight: Statistical analysis of the data showed that the effect of N rates on 500 kernel weight was significant while herbicides and the interaction of N and herbicides were non-significant (P<0.05; Table 1 and 2). The heaviest 500 kernel weight (92.8 g) was recorded for 160 kg ha^{-1} N treated plots while the lightest (85.2 g) for 80 kg ha^{-1} N treated plots (Table 2). The average heaviest 500 kernel weight (91.5 g) was found for Atrazine treated plots and the lightest (85.8 g) for the weedy check plots (Table 2). For the interaction (N rates x herbicides), the maximum 500 kernel weight (95.5 g) was noted for 2,4-D x 160 kg ha^{-1} N while the least (81.5 g) for the weedy check (Table 2). Our results are confirm the findings of Akmal *et al*. (2010) who found significant increase in the 1000 grain weight of maize when the crop growth was supplemented with higher rates of N fertilizer and Hussein *et al*. (2007) have also found that the application of N fertilizer at higher rates had promoted growth of most maize parameters. On the other hand, Janjic *et al*. (1983) and Knezevic and Dukic (1996) have found comparatively greater weight of 500 kernel of maize by controlling weeds in the crop with the application of herbicide than the weedy check.

The biological yield: Data regarding biological yield of maize was significantly affected by the N rates and herbicidal treatments, however, their interaction effect was found non-significant (P<0.05; Table1). For the N rates, the highest biological yield (3.1 and 3.o t ha^{-1}) was obtained from plots applied with 160 and 120 kg ha^{-1} N, respectively while lowest in plots applied with 80 kg ha^{-1} N (Table 2). Regarding herbicides, the highest biological yield (3.1, 3.2 and 3.0 t ha^{-1}) was found for Atrazine, Stomp and 2,4-D, respectively and lowest in the weedy check plots (Table 2). The average highest biological yield (3.4 t ha^{-1}) was recorded for the interaction plots (Atrazine x 160 kg ha^{-1} N rate) while the minimum (2.2 t ha^{-1}) for the interaction plots (weedy check x 80 kg ha^{-1} N rate; Table 2). The highest biological yield production of maize at the 160 kg N ha^{-1} may be due to the efficient N uptake by the crop plants while the weeds may not be able to utilize it efficiently. These results are in line with Bakht *et al*. (2007) who reported the application of N fertilizer at higher rates to be useful in increasing various growth and yield components of maize crop in Peshawar. Similarly, Hussein *et al*. (2007) have found that N fertilizer addition had greatly increased various yield components of maize and Subhan *et al*. (2007) and Ali *et al*. (2003) have also demonstrated significant increase of maize production due to weed control by herbicides.

Conclusion: The application of both higher rate of N fertilizer and use of herbicides for controlling weeds in maize had greatly increased the various growth parameters of maize. The 50% silking was highest for atrazine treatment and 160 kg N ha^{-1} application. The 500 kernel weight and the biological yield of maize were increased with the application of N (at 160 kg ha^{-1}) and herbicides (Atrazine and Stomp) at their recommended rates as compared to weedy check.

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