VOL. 11, NO. 9, SEPTEMBER 2016 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

SOIL AMENDMENTS IMPROVED GROWTH AND PRODUCTION OF MAIZE (*Zea mays* L.) UNDER IRRIGATED AND RAINFED CONDITION IN SEMIARID REGION OF NORTHWEST, PAKISTAN

Amanullah Jan[1], Shahzad Ali[1], Jia Zhikuan[2], Zheng Peng[2], Wei Ting[2] and Cui Wenwen[2]
[1]Department of Agronomy, the University of Agriculture, Peshawar, Pakistan
[2]College of Agronomy, Northwest A&F University, Yangling, China
E-Mail: shahzadali320@aup.edu.pk

ABSTRACT

Poor growth and production in maize (*Zea mays* L.) under irrigated and rain-fed condition is a serious concern world-wide. Soil amendments could be an effective approach in increasing maize growth and production in irrigated and rain-fed conditions. Therefore field trials were conducted during summer 2011-2012 at New Developmental Farm of The University Agriculture, Peshawar, Pakistan. The field experiments were layout in randomized complete block design having three replications. To efficiently utilize the already scarce water within the cultivated field, two way agronomic approaches were adopted in this study. The first one relates to irrigation. An irrigation levels that is designated as full irrigation as per the farmers' practice where six irrigations are normally applied and the other experiment was designated under rain-fed conditions. The second approach was the application of soil amendments to retain the moisture within root zone. Both conventional (FYM (10 t ha^{-1}), crop residue (wheat straw 10 t ha^{-1}) and non-conventional (gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1}) were added as soil amendments. The results of the 2nd year research shows that the plots grow under irrigated condition improved growth and production of maize crop as compared to rain-fed conditions. Plots treated with 10 tons FYM ha^{-1} produced maximum LA (317 cm^2), LA $plant^{-1}$ (3329 cm^2), LAI (2.74), CGR (30.4 g m^{-2} d^{-1}), NAR (2.48 g cm^{-2} d^{-1}), thousand grain weight (287.4 g),grain yield (3896 kg ha^{-1}) and biomass yield (14345 kg ha^{-1}) as compared with other soil amendments but statistically at par such as humic acid. FYM had increased grain and biomass yield by 15 and 46% respectively over control. Adequate and well distributed rainfall in the 2nd year caused to produce more LA (0.44%), LA $plant^{-1}$ (4.8%), CGR (0.03%), grain yield (2.6%) and biomass yield (5.3%) over first year. It can be concluded that that plots treated with FYM or humic acid under irrigated condition was better than other treatments.

Keywords: soil amendments, irrigation schedule, LA, LAI, CGR, NAR, biomass, maize.

1. INTRODUCTION

Maize (*Zea mays* L.) average yield in the project area is below 2000 kg ha^{-1} (MINFA, 2012) against the national yield of the crop which is 3805 kg ha^{-1}. Soil and climatic conditions of Pakistan are highly favourable for maize production yet its average yield is very low. Among the various factors of crop production, irrigation schedule, soil amendments and improved maize cultivars play a key role in boosting its production. Losses in maize yield due to drought stress ranges from 15% to 90% and indicate water shortage is one of the major concern affecting crop productivity throughout the world (Lafitte, 1994). Reductions from 15 to 30 % in yield due to water shortage or drought as compared with no stress have been reported by Lafitte (1994). Efforts to conserver the moisture with conventional and improved conservative techniques including soil amendments both natural and synthetic are under way to coup with sacristy of water. Polymeric organic materials and hydrogels apart from improving the soil physical properties used soil amendments serve as buffers against temporary drought stress and reduce the risk of plant failure during establishment (De Boodt 1990). This is achieved by means of reduction of evaporation through restricted movement of water from the sub-surface to the surface layer (Qian *et al*., 2004). The influence of synthetic soil conditioners on the growth of plants have, so far, been investigated using linearly polymerized polyacrylamides that have, rather, low content of carboxylic groups (Wallace and Nelson, 1986). Rehman, (1996) reported that crop residues improve soil humus content, water holding capacity, cation exchange capacity and conserve moisture. Crop residues on decomposition, supply plant nutrients to the succeeding crops. Keep the soil in better physical condition, made soil permeable, increase water infiltration, water holding capacity and improving its supply to the plants Mohanty *et al*, (2010). Wang and Zhao (1991) observed that crop residues with 3.75-4.5 tons ha^{-1} of mung bean straw is an effective measure to reduce inter-plant evaporation from a wheat paddock and yield more with reduced water consumption. Gypsum is almost a universal soil amendment (Wallace and Nelson 1986) can reduce soil crusting, improve water infiltration, improves water transmission (conductivity Increased water absorption), and increased recovery of N from subsoil. It increases water use efficiency and improve water retention and infiltration in soil as compared with control (Farina *et al*., 2000). Gypsum stimulates tillering which may be due to increased availability of nitrogen, with the improved aeration that follows gypsum application (Rixon, 1970). Farm yard manure also improves the pH of the moderately acidic soils if applied repeatedly over several seasons. It's a good source of K and N. Therefore, it is hoped that the use of FYM alone or in combination with fertilizers will gradually improve and sustain soil productivity over the years (Mwangi, 2010). Humic acid (HA) is used in agriculture and industry (Sharif *et al*. 2003). Can serve as a catalyst in promoting the activity of microorganisms in soil (Atak and Kaya. 2004). As a fertilizer, plant growth promoter, nutrient carrier, and soil conditioner (Nisar and Mir, 1989). Keeping in view the yield gap of maize of Khyber Pakhtunkhwa, the present research were carried out to find out the most suitable soil amendment and irrigation schedule for conservation of water within the root-zone and their effect on maize growth and production.

2. MATERIALS AND METHODS

2.1. Experimental site, design and agronomic management

This research was carried out at New Developmental Farm of The University of Agriculture, Peshawar (34° 00' N, 71° 30' E, 510 MASL) Pakistan during summer 2011- and repeated in 2012. Metrological data were recorded at weather station located at the experimental site (Figure-1). The experiment was carried out in randomized complete block design having three replications. Two separated filed experiments were maintained. Treatments were randomized in each field. One filed was specified for irrigation while other had rain-fed condition. Six irrigations are given at six growth stage emergence, four leaves stage, eight leaves stage, tasseling stage, blister stage and dough stage. The treatments consisted of soil amendments (FYM (10 tons ha^{-1}), crop residue (CR) (wheat straw 10 tons ha^{-1}), gypsum (GYP) (1000 kg ha^{-1}), qemisoyl (QEM) (10 kg ha^{-1}) and humic acid (HA) (12 kg ha^{-1})) were used. A subplot size of 4 x 4.2 m was used. Each sub-plot was consisted of 6 rows having 70 cm row-to-row distance. Nitrogen was applied at the rate of 120 kg ha^{-1} Half of N was applied at sowing time while remaining half was at 6^{th} leaf stage of crop. At the same time, in all experimental treatments, phosphorus and potassium fertilizers were applied at a rate of 90 and 40 kg of nutrient ha^{-1}, respectively. Both years maize crop was planted at normal planting times with the seed rate of 30 kg ha^{-1} on June 10, 2011 and June 12, 2012 and using maize cultivar Azam. Recommended agronomic practices were carried out uniformly for all the experimental units throughout the growing season 2011-12. Physico-chemical properties of the soil was analysed the analysis showed in (Table-A).

2.2. Experimental and data recording procedure

Leaf area was measured by collecting leaves from five plants of each plot at tasseling stage and their leaf area (LA) was calculated (Khalil et al., 2002) and averaged as leaf area $plant^{-1}$. Leaf area index (LAI) was calculated by dividing the leaf area over ground area. One meter long row was selected in each plot data was taken at three growth stages of the crop (i) 6 leaf stage (ii) grain filling (iii) physiological maturity and NAR was calculated by the following formula. NAR = $[(W_2-W_1) / (T_2-T_1) \times (\ln L_2 - \ln L_1 / L_2 - L_1]$ (g cm^{-2} d^{-1}). Five plants in each plot were randomly selected and were dried at 70 ºC for 72 hours to determine their dry weight at (i) 6 leaf stage (ii) grain filling (iii) physiological maturity from the date of sowing. The following formula was used to record crop growth rate in g d^{-1} m^{-2}. CGR = $[(W_2-W_1) / (T_2-T_1) \times (1/GA)]$ g d^{-1} m^{-2}. Thousand grains were counted at random from each treatment and weighed with the help of a sensitive electronic balance to record1000-grain weight. Grains yield was recorded after shelling of ears of four central rows from each plot and then dried, and weighted and converted into kg ha^{-1}. For biomass yield, four central rows of each plot were harvested, sun dried, weighed and converted into kg ha^{-1}. Economic analysis was calculated by the following formula (CIMMYT, 1988).

a) Gross income = Grain yield value + straw yield value

b) Net income = Gross income – total expenditure

2.3. Statistical analysis

Data were analyzed using the statistical package MSTAT-C (Steel and Torrie 1980) and the significant differences among the treatments were determined using least significant difference (LSD) test at 5% level of probability.

Table-A. Physico-chemical properties of experimental site at AUP, Peshawar.

Parameters	Year (2011)	Year (2012)
PH	7.91	7.98
Lime ($CaCO_3$)	15.4	17.2
Organic matter (g kg^{-1})	1.50	1.69
Total nitrogen (g kg^{-1})	4.25	5.46
Texture class	Silty clay loam	Silty clay loam
Clay (%)	32.90	32.90
Silt (%)	53.20	53.20
Sand (%)	13.90	13.90
EC (sc) (ds cm^{-1})	0.12	0.14
Bulk Density (Mg m^{-3})	1.43	1.45
Porosity (%)	45.95	46.1
AB-DTPA extractable P mg Kg^{-1}	5.76	5.79

3. RESULTS AND DISCUSSIONS

3.1. Weather data

During 2^{nd} growing season (2012) the weather was cooler and wetter as compared to first growing season (2011). Total seasonal rainfall in 2^{nd} growing season (517 mm) which was almost (180 mm) of rainfall is increase as compare to first growing season (337 mm). Rainfall in the 2^{nd} growing season was well distributed receiving 85 mm

VOL. 11, NO. 9, SEPTEMBER 2016 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

in June, 100 mm in July, 95 mm in August and 110 mm in September, while in first year it was 50, 38, 100 and 48 mm in the subsequent months (Figure-1). The rainfall during 2nd year was enough for seed germination, growth and development of maize. However, the favourable environment in the 2nd growing season improved growth and production of maize as compared with first growing season crop.

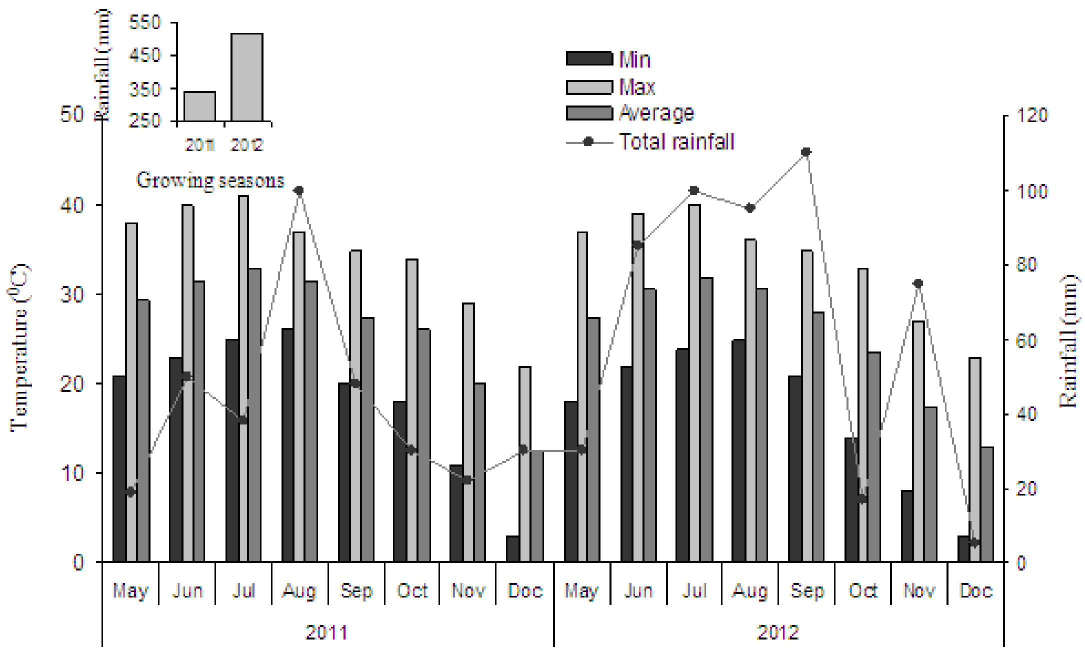

Figure-1. Average air temperature and rainfall at Metrological station Pakistan Forest Institute Peshawar, Pakistan during the crop growing season (2011) and (2012).

3.2. Leaf area (cm^2)

Year (Y), irrigation schedule (I) and soil amendments significantly affected leaf area (LA), whereas all the interactions was found non-significant indicating in (Table-1). Statistical analysis of two years data showed that maize produced maximum LA cm^2 (321) in the 2nd year (2012) and minimum LA cm^2 (277) in the first year (Table-1). Production of maximum LA in 2nd year may be attributed to precipitation quantity and its well distribution in September (Figure-1) when plant needed moisture for LA formation and growth. Moreover, rainfall in the second year provided more favourable environment for LA growth and development. Maize crop sown under irrigated conditions produced maximum LA cm^2 (337) while minimum maximum LA cm^2 (261) was recoded when maize crop sown under rain-fed conditions. These results are in line with those of Giri *et al*. (2009) who reported 15% reduction in LA cm^2 with reducing irrigation from 8 to 4 numbers. Reduction in LA cm^2 might be due to water stress as a result shorter leaf length and width as compared with irrigated plots. Mean values over two year data revealed that FYM or Crop Residue (CR) use as a soil amendments produced maximum LA cm^2 (317), whereas minimum LA cm^2 (230) were recorded from control. Findings of the current study are in line with the results of Singh et al., (2004) who reported that FYM improved soil fertility status by adding major and minor nutrients as well as soil organic matters which improve moisture and nutrient holding capacity as a result leaf area cm^{-2} increased as compared with other soil amendments.

3.3. Leaf area plant^{-1} (cm^2)

Table-1 showed that leaf area plant^{-1} was significantly affected by Y, I and SA, while all the interactions were found statistically non-significant. Larger leaf area plant^{-1} (3231 cm^2) was recorded in 2nd year compared to smaller leaf area plant^{-1} (2745 cm^2) in the first year (Table-1). Higher rainfall and lower temperature in July and August in the 2nd year probably may have superior the crop that resulted in abundant plant growth and development so larger leaf area plant^{-1} was produced than first year. Leaf area plant^{-1} increased under irrigated conditions and attained (2696 cm^2) was recorded while minimum leaf area plant^{-1} (2349 cm^2) was produced when maize crop grow under rain-fed conditions. Results of the current study agree with the findings of Rasool et al., (2005) who reported that significantly decreased occurred in leaf area plant^{-1} with decreasing number of irrigation from 8 to 4 levels. Reductions of 15 to 20 % in leaf area plant^{-1} might be due to water stress or drought at growth and development stage of leaf as compared with no stress. Production of larger leaves from FYM treated plots compared with control plots probably may be attributed FYM improved soil fertility status of soil and as well as soil organic matters which improve moisture and enhanced plant nutrients uptake which accelerated photosynthesis, and thus produced bumper crop with larger leaves as compared with control plots. These results were given in line with those of Todorova (2000) who recorded maximum leaf area plant^{-1} when plots treated with FYM as compared with control plots.

3.4. Leaf area index

Data regarding leaf area index (LAI) given in (Table 1) revealed that Y, I and SA had significantly affected (LAI) while all the interactions were found statistically non-significant. Two years data indicated that 2nd year crop produced high LAI (2.58) compared with low LAI (2.46) observed in the first year (Table 1). Higher LAI values in the 2nd year are endorsed to larger leaf area and more leaf area plant^{-1} in the 2nd year which eventually led to high LAI. Maize crop grow under irrigated conditions produced high LAI (2.60) while low LAI (2.45) was produced when maize crop grow under rain-fed conditions. These results confirm the findings of Lafitte (1994) who reported that reductions in LAI might be due to water stress during leaves growth and development stage as a result LAI decrease with decreasing number of irrigations or grow maize crop under rain-fed conditions. Mean values over two year data showed that Plots treated with FYM at 10 t ha^{-1} Produced higher LAI; whereas control plots produced lower LAI. Higher LAI from plots treated with SA may be attributed to production of more leaves of larger size compared with control plots. These results are supported by Rasool *et al*., (2005) who observed that different SA such as FYM, CR and Qemisoyl had improved soil fertility status of soil as well as soil organic matters which improve moisture and nutrient holding capacity as a result increased photosynthetic activities, reduced evaporation and finally increased leaf area and leaf area index as compared with other soil amendments and control plots.

3.5. CGR (g m^{-2} day^{-1})

Mean values of two years data revealed in (Table-1) that crop growth rate (CGR) was significantly effect by Y, I and SA while all the interactions were found statistically non-significant. Crop of the 2nd year produced higher CGR (27.3 g m^{-2} day^{-1}) as compared with first year crop produced (24.3 g m^{-2} day^{-1}). The possible reason could be that FYM and crop residue during first year decomposed and become available during 2nd year crop as a result CGR increased in fact that 2nd year crop received `2 % more rainfall, organic matter increase from 1.50 to 1.69 g kg^{-1} and total nitrogen in soil is increase from 4.25 to 5.46 g kg^{-1} as compared with first year crop. CGR increased when maize crop grow under irrigated conditions and attained (30.1 g m^{-2} day^{-1}) while minimum CGR (20.9 g m^{-2} day^{-1}) was produced under rain-fed conditions. These results were given in line with those of Todorova (2000) who reported that significantly reductions 13 to 16% in CGR occur might be due to water stress or drought which effects the growth of crop as compared with no stress. Soil amendments had significant effect on CGR. Plots treated with FYM at 10 t ha^{-1} produced higher (30.4 g m^{-2} day^{-1}) and statistically at par when plots treated with humic acid, while lowest CGR (15.4 g m^{-2} day^{-1}) were recorded in control plots. These results agree with the findings of Rasool et al., (2005) who reported that FYM improved soil fertility status of soil and as well as soil organic matters which improve moisture and nutrient holding capacity as a result increased photosynthetic activities, reduced evaporation and finally increased CGR as compared with control plots.

3.6. NAR (g cm^{-2} day^{-1})

Statistically analysis of two years data showed in (Table-1) that net assimilation rate (NAR) was significantly effect by I and SA while year and all the interactions were found statistically non-significant. NAR increased when maize crop grow under irrigated conditions and attained (2.61 g cm^{-2} day^{-1}) while minimum NAR (1.99 g cm^{-2} day^{-1}) was produced under rain-fed conditions. These results were given in line with those of Mohanty et al, (2010) who reported that significantly reductions 9 to 14% in NAR occur might be due to water stress or drought which effects the growth and development of crop as compared with irrigated plots. Soil amendments had significant effect on NAR. Plots treated with FYM at 10 t ha^{-1} produced higher (2.48 g cm^{-2} day^{-1}) and statistically at par when plots treated with humic acid, while lowest NAR (1.84 g cm^{-2} day^{-1}) were recorded in control plots. These results agree with the findings of Rasool et al., (2005) who reported that FYM improved soil fertility status of soil and as well as soil organic matters which improve moisture and nutrient holding capacity as a result increased photosynthetic activities, reduced evaporation and finally increased NAR as compared with control plots.

3.7. Thousand grains weight (g)

Soil amendments, year and irrigation schedule significantly affected thousand grains weight, while all the interactions were found non-significant (Table 1). Crop of the 2nd year produced heavier grains weight (278.2 g) as compared with first year crop produced (263.4 g). The possible reason could be that FYM and crop residue during first year decomposed and become available during 2nd year crop as a result grains weight increased as compared with first year crop. Grains weight increased under irrigated conditions and attained heavier grains weight (283.3 g) was recorded while lighter grains weight (258.5 g) was produced when maize crop grow under rain-fed conditions. These results were given in line with those of Todorova (2000) who reported that significantly decreased in grains weight occur when crop grow under rain-fed conditions. Reductions of 10 to 17 % in grains weight might be due to water stress or drought at grain filling stage as compared with irrigated conditions. Mean values over two years revealed that soil amendments significant effect on grains weight. Plots treated with FYM at 10 t ha^{-1} produced heavier grains weight (287.4 g) and statistically at par when plots treated with humic acid, while lighter grains weight (164.1 g) were recorded in control plots. These results agree with the findings of Rasool et al., (2005) who reported that FYM improved soil fertility status of soil and as well as soil organic matters which improve moisture and nutrient holding capacity as compared with control plots.

3.8. Grain yield (kg ha^{-1})

Statistical analysis of the data showed that Y, I and SA significantly affected grain yield, the Y x I x SA, interaction was found significant while the remaining interaction were statistically non-significant (Table-1). Two years data showed that 2nd year crop produced maximum grain yield (3817 kg ha^{-1}) as compared with first year produced lower grain yield (3555 kg ha^{-1}). Higher grain yield in the 2nd year may be due higher and well distributed rainfall particularly at silking and grain filling stage and higher rainfall in the months of June, July and August (Figure-1). Higher rainfall and lower temperature from June to September might have provided conducive environment for growth and development which ultimately caused higher grain yield production. The decomposition of FYM and crop residue applied during first year become available during 2nd year crop as a result grain yield increased in addition to organic matter increase from 1.50 to 1.69 g kg^{-1} and total nitrogen in soil is increase from 4.25 to 5.46 g kg^{-1} in 2nd year as compared with first year crop. Grain yield increased under irrigated conditions and attained maximum grain yield (3813 kg ha^{-1}) was recorded while minimum grain yield (3458 kg ha^{-1}) was produced when maize crop grow under rain-fed conditions. These results agree with the findings of Giri *et al*. (2009) who reported that significantly decreased in grains weight occur when crop grow under rain-fed conditions. Reductions of 13 to 19 % in grain yield might be due to water stress or drought at grain filling stage which reduces thousand grains weight and increase inter-plant competition as a result grain yield is reduce as compared with irrigated plots. Soil amendments had significant effect on grain yield. Plots treated with FYM at 10 t ha^{-1} produced maximum grain yield (3896 kg ha^{-1}) and were statistically at par when plots treated with humic acid, while minimum grain yield (2413 kg ha^{-1}) was recorded in control plots. These results agree with the findings of Farhad *et al*. (2009) who reported that grain yield significantly increased with increasing FYM from 1 to 1.5 tons ha^{-1}. FYM improved soil fertility status of soil which improve moisture and nutrient holding capacity as a result grain yield increased as compared with control plots. The three way interaction Y x I x SA for grain yield given (Fig. 2) revealed that during both years grain yield increased significantly with FYM under both irrigated and rain-fed conditions as compared with other soil amendments. Linear increased in grain yield was recorded when maize crop grow under rain-fed conditions and treated with FYM as soil amendment during 2nd year, however sharply decreased in grain yield produced when plots treated with gypsum under rain-fed conditions during both years.

3.9. Biomass Yield (kg ha^{-1})

Biomass yield present in (Table 1) showed that Y, I and SA significantly affected biomass yield, the Y x I x SA, interaction was found significant while the remaining interaction were statistically non-significant. Two years data showed that 2nd year crop produced maximum biomass yield (14125 kg ha^{-1}) as compared with first year produced lower biomass yield (13592 kg ha^{-1}). Higher biomass yield in the 2nd year may be due higher and well distributed rainfall particularly at all growth stages and higher rainfall in the months of June, July and August (Figure-1). Higher rainfall and lower temperature from June to September might have provided favourable environment for growth and development which ultimately caused higher biomass yield production. The decomposition of FYM and crop residue applied during first year become available during 2nd year crop as a result biomass yield. Biomass yield increased under irrigated conditions and attained maximum biomass yield (14610 kg ha^{-1}) was recorded while minimum biomass yield (11927 kg ha^{-1}) was produced when maize crop grow under rain-fed conditions. These results agree with the findings of (Mwangi, 2010) who reported that significantly decreased in biomass weight occur when crop grow under rain-fed conditions. Reductions of 16 to 23 % in biomass yield might be due to water stress or drought at different growth stages which reduces biomass and increase inter-plant competition as a result biomass yield is reduce as compared with irrigated plots. Soil amendments had significant effect on biomass yield. Plots treated with FYM at 10 t ha^{-1} produced maximum biomass yield (14345 kg ha^{-1}) and were statistically at par when plots treated with humic acid, while minimum biomass yield (9716 kg ha^{-1}) was recorded in control plots. These results agree with the findings of Farhad *et al*. (2009) who reported that biomass yield significantly increased with addition of soil amendments. The three way interaction Y x I x SA for biomass yield given (Figure-3) showed that during both years biomass yield increased significantly with FYM under both irrigated and rain-fed conditions as compared with other soil amendments. Linear increased in biomass yield was recorded when maize crop grow under rain-fed conditions and treated with FYM as soil amendment during 2nd year, however sharply decreased in biomass yield produced when plots treated with gypsum under rain-fed conditions during both years.

3.10. Economic analysis

Economic analysis for the treatment imposed (Table-2) reveals that maize crop grow under irrigated conditions had an advantage of merely (2%) as compared with rain-fed conditions. Among the SA both FYM and humic acid at the rate of 10 tons ha^{-1} and 12 kg ha^{-1} as sole had the highest rate of return (32%) and was closely followed by crop residue (30%).

VOL. 11, NO. 9, SEPTEMBER 2016 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

Table-1. Leaf area, Leaf area plant^{-1}, LAI, CGR, NAR, thousand grains weight, grain yield and Biomass yield of maize as affected by irrigation schedule and soil amendments during the two years research 2011 and 2012.

Treatment	LA (cm^2)	Leaf area plant^{-1} (cm^2)	LAI	CGR (g m^{-2} day^{-1})	NAR (g cm^{-2} day^{-1})	1000 grains weight (g)	Grain yield (kg ha^{-1})	Biomass yield (kg ha^{-1})
Year (Y)								
2011	277 b	2745 b	2.46 b	24.3 b	2.29	263.4b	3555b	13592 b
2012	321 a	3231 a	2.58 a	27.3 a	2.34	278.2a	3817a	14125 a
Irrigation (I)								
Irrigated	337 a	2696 a	2.60 a	30.1a	2.61 a	283.3a	3813a	14610 a
Rainfed	261 b	2349 b	2.45 b	20.9 b	1.99 b	258.5b	3458b	11927 b
Soil Amendments (SA)								
Control	230 e	2070 e	2.02 e	15.4 d	1.84 e	164.1d	2413d	9716 e
Farm Yard manure	317 a	3329 a	2.74 a	30.4 a	2.48 a	287.4a	3896a	14345 a
Crop Residue (CR)	310 a	2790 c	2.53 c	26.1 b	2.30 b	271.2b	3704b	13929 b
Gypsum (GYP)	274 d	2466 d	2.42 d	22.8 c	2.16 d	248.3c	3618c	13127 d
Qemisoyl (QEM)	295 c	2655 c	2.44 d	22.7 c	2.23 c	263.1b	3624c	13579 c
Humic acid (HA)	307 b	3070 b	2.66 b	29.6 a	2.44 a	278.5a	3833a	14108 a
LSD (0.05)	6.5	175	0.09	2.5	0.05	14	76	235
Interaction								
Y x I	ns	ns	ns	ns	ns	ns	ns	ns
Y x SA	ns	ns	ns	ns	ns	ns	ns	ns
I x SA	ns	ns	ns	ns	ns	ns	ns	ns
Y x I x SA	ns	ns	ns	ns	ns	ns	*	*

Means in the same category followed by different letters are significantly different at $P \leq 0.05$ levels using LSD test. ns = non-significant * = significant

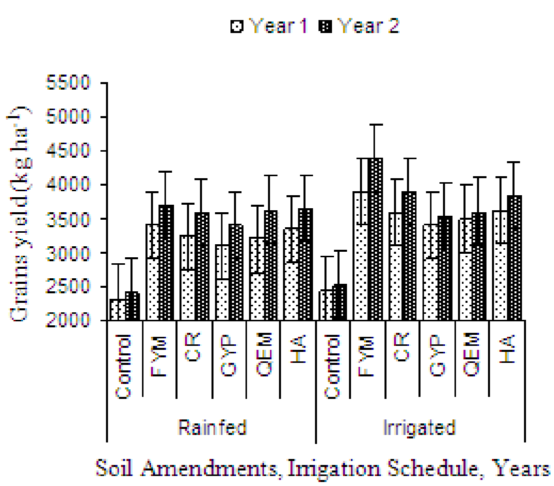

Figure-2. Grain yield of maize as affected by irrigation schedule and soil amendments during 2011-12.

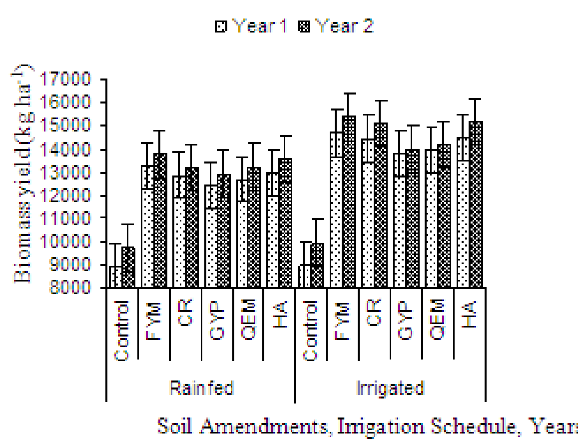

Figure-3. Biomass yield of maize as affected by irrigation schedule and soil amendments during 2011-12.

ARPN Journal of Agricultural and Biological Science

Table-2. Soil amendments and irrigation schedule effect on economic return (Rs. ha^{-1}) of maize at experimental site AUP Peshawar. (2011-2012).

	Cost that very (Rs)	**Grain yield value** (Rs)	**Stalk yield value** (Rs)	**Total value** (Rs) **(2+3)**	**Net return** (Rs) **(4-1)**	**Increase over control** (%)
Irrigation						
Irrigated	23200	265275	122415	378690	355490	1.6
Rainfed	11600	249375	111888	361263	349663	-
Soil amendments						
Control	0	60325	60325	303225	303225	0
Farm Yard manure	10600	97400	97400	456025	445425	32
Crop Residue (CR)	7600	92600	92600	440825	433225	30
Gypsum (GYP)	2600	90450	90450	418625	416025	27
Qemisoyl (QEM)	36600	90600	90600	430075	393475	23
Humic acid (HA)	1100	95825	95825	448525	447425	32

4. CONCLUSIONS

Higher rainfall, low temperature and decomposition of FYM and CR in the 2nd year improved LA, leaf area $plant^{-1}$, LAI, CGR and enhanced grain and biomass yield. Maize crop grow under irrigated condition improved LA, LAI, NAR, CGR, grain and biomass yield as compared with rain-fed conditions. Soil amendments such as FYM or humic acid enhanced LA, LAI, CGR, NAR and biomass yield. However, soil amendments such as FYM was more beneficial as it produced heavier grains weight, grain and biomass yield under irrigated conditions of Northwest, Pakistan. The farmers will gain more production and profit if maize crop grow under irrigated conditions and used FYM as a soil amendment for obtaining maximum grain and biomass under similar soil and climatic conditions.

ACKNOWLEDGMENTS

This work was supported by Higher Education Commission (HEC) Islamabad for providing financial support. These studies would never have possible without the active involvement of (HEC), Prof. Dr. Amanullah Jan and Prof Dr. Jia Zhikuan his kind personal interest and consistent advice and encouragement.

REFERENCES

Atak M., Kaya M. 2004. Effect of zinc and HA application on yield and yield components of durum wheat. Anadolu. 14(2): 49-66.

CIMMYT. 1988. An economic training manual; from agronomic data to farmer recommendations. Mexico. 1-25.

De Boodt M. 1990. Application of polymeric substances as physical soil conditioners. In Soil colloids and their association in soil aggregates. 580-592. Planum Publishing Corporation, London, New York.

Farhad W., Saleem M.F., Cheema M.A., Hammad H.M. 2009. Effect of farm yard manure levels on the productivity of spring maize J. Ani. Pl. Sci. 19(3): 122-125.

Farina M.P.W., Channon P., Thibaud G.R. 2000. A comparison of strategies for ameliorating subsoil acidity: I. Long- term growth effects. Soil Sci. Soci. Am. J. 64, 646-651.

Giri U., Bandyopadhyay p., Chakraborty A. 2009. Effect of irrigation and weed management on grain yield, soil moisture depletion pattern and WUE of hybrid maize under West Bengal condition. J. Agron. 15, 423-435.

Khalil S.K., Zeb K., Khan A.Z. 2002. Changes in leaf area, assimilate accumulation and partitioning of wheat varieties planted on different date. Pak. J. Soil Sci. 21, 15-19.

Lafitte. 1994. Identifying production problems in Tropical maize . A field guide: Mexico, L.F. CIMMYT. p. 4.

MINFA. 2012. Ministry for food, Agriculture, Agriculture Statistics of Pakistan. Govt. of Pak, Economic Wing, Islamabad.

Mohanty M.M., Probert E., Reddy K.S., Dalal R.C., Rao A.S. and Menzies N.W. 2010. Modelling N mineralization from high C:N rice and wheat crop residues. World Congress of Soil Science, Soil Solutions for a Changing World 1-6 August 2010, Brisbane, Australia.

ARPN Journal of Agricultural and Biological Science

Mwangi T.J. 2010. Improving and sustaining soil fertility by use of farm yard manure and inorganic fertilizers for economical maize production in West Pokot, Kenya. World J. Agric. Sci. 6(3): 313-321.

Nisar A., Mir S. 1989. Lignitic coal utilization in the form of HA as fertilizer and soil conditioner. Sci. Tech. Develop. 8, 23-26.

Qian P., Schoenau J.J., Wu T., Mooleki P. 2004. Phosphorus amounts and physical properties as affected by long-term application of FYM and inorganic fertilizers in maize-wheat system. Soil and Tillage Res. 10(4): 41-66.

Rasool R., Kukal S.S., Hira G.S. 2005. Soil organic carbon and physical properties as affected by long-term application of FYM and inorganic fertilizers in maize-wheat system. Soil and Tillage Res. 101(2): 31-36.

Rehman H. 1996. Keynote address In 5th National congress of soil science held in Peshawar (Oct 23-25. 1994), Pak. J. Soil science. 11(2): 145-149.

Rixon A.J. 1970. Effect of applied gypsum on the yield and herbage nitrogen of an irrigation pasture. Proc. 11th Int. Grassland Congr. 472-475.

Sharif M., Khattak R.A., Sarrir M.S. 2003. Residual effect of humic acid and chemical fertilizers on maize yield and nutrient accumulation. Sarhad. J. Agric. 19(4): 543-550.

Singh N., Athokpa J., Patel H.S. 2008. Effect of FYM and pressmud on maize (*Zea mays* L.) and availability of nutrients in the soil of Sardar Sarover Punarvasavat Agency (SSPA) Rehabilitated Sites. Environ. Ecol. 26, 160-165.

Steel R.G.D., Torrie J.H. 1980. Analysis of Covariance. *In*: Principles and Procedures of Statistics. A Biometrical Approach. 2nd Ed., McGraw-Hill New York. 401-437.

Todorova N., Stratieva S. 2000. Effect of irrigation, fertilization, soil tillage yield potential, yield stability and stress tolerance in maize. Field Crops Research. 75, 161-169.

Wallace A., Nelson S.D. 1986. Foreword (special issue on soil conditioners) Soil Sci. 141, 311-312.

Wang Y.K., Zhao S. 1991. The study on soil moisture preservation by straw coverage of a Yanzhuang wheat paddock. Proceedings International Commission on Irrigation and Drainage Special Technical session Beijing, China. Vol. I-C Irrigation Management. 134-145.