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Impact of Soil Amendments on Yield and Yield Attributes of Maize (Zea mays L.) under Different Irrigation Schedule

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Abstract
Field trials were conducted during summer 2011-2012 at New Developmental Farm of The University Agriculture, Peshawar, Pakistan to study the effects of soil amendments on yield and yield attributes of maize (*Zea mays* L.) under different irrigation schedule. The field experiments were layout 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 6 irrigation while other had 3 irrigation. The treatments consisted of soil amendments (FYM (10 t ha^{-1}), crop residue (wheat straw 10 t ha^{-1}), gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1})) were used. Irrigation had significant effect on all parameters except ears plant^{-1}, shelling (%) and harvest index. Plots supplied with six irrigations produced maximum grains ear^{-1} (496), grains weight (283.3 g) and grain yield (3813 kg ha^{-1}) as compared with three irrigations. Soil amendments had significantly affected yield and yield components of maize. Plots treated with 10 tons FYM ha^{-1} produced maximum ears plant^{-1} (1.5), grains ear^{-1} (504), shelling (73 %), grains weight (287.4 g), grain yield (3896 kg ha^{-1}) and harvest index (28.4 %) as compared with other soil amendments but grains ear^{-1}, 1000 grains weight and grain yield were statistically at par with other soil amendments such as humic acid. It was concluded from the experiment that plots treated with FYM at the rate of 10 t ha^{-1} having six irrigations improved maize productivity and thus, is recommended for general practice in agro-climatic conditions of Peshawar valley.
Keywords: Maize, soil amendments, humic acid, irrigation schedule, qemisoyl, crop residue, gypsum, yield components

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 favorable 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 & 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 & 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 experiment 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 yield and yield components.

MATERIALS AND METHODS

This research was carried out at New Developmental Farm of The University of Agriculture, Peshawar (34^o 00' N, 71^o 30' E, 510 MASL) Pakistan during summer 2011-2012. 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 6 irrigation while other had 3 irrigation. Six irrigations are given at six growth stage emergence, four leaves stage, eight leaves stage, tasseling stage, blister stage and dough stage. Three irrigations are given at three critical growth stage four leaves stage, tasseling stage and dough stage. The treatments consisted of soil amendments (FYM (10 tons ha^{-1}), crop residue (wheat straw 10 tons ha^{-1}), gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1})) were used. A subplot size of 4 x 4.2 m having 6 rows with row-to-row distance of 70 cm. Phosphorous was applied at the rate of 90 kg ha^{-1} and nitrogen at the rate of 120 kg ha^{-1}. Half of N was applied at sowing time while remaining half was at 6th leaf stage of crop. Crop was sown in the 3rd week of June at seed rate of 30 kg ha^{-1} using maize cultivar Azam. Recommended cultural practices were followed throughout the growing period. Number of ears plant^{-1} was counted in ten plants selected randomly in each subplot. Number of grains ear^{-1} was recorded by selecting five ears randomly from each plot counted number of grains ear^{-1} and averaged. Shelling percentage was calculated grains weight of five ears dividing by weight of five ears and multiplies by 100. Thousand grains weight (g) were recorded from three seed lot and weighted with the help of electronic sensitive balance. Four central rows in each sub plot were harvested, sun dried and threshed. Grain weight was taken with the help of electronic balance and then converted into kg ha^{-1}.

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. Rainfall (mm) data of experimental site for two growing season (2011-2012) of the maize crop.

Month	Mean rainfall (mm)	
	Year-2011	Year-2012
June	41	52
July	53	100
August	122	120
September	38	90
Total	254	362

Source: Metrological station Pakistan Forest Institute Peshawar.

Mean rainfall (mm) data for two crop season shows that 2nd year (2012) had 42% more rainfall as compared with 1st year of experiment (2011).

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

Parameters	**Year (2011)**	**Year (2012)**
PH	8.2	8.73
Lime (%)	19	21.2
Organic matter (g kg^{-1})	1.50	2.04
Total nitrogen (g kg^{-1})	4.25	7.46
Texture class	Silty clay loam	Silty clay loam
Clay (%)	40.2	40.2
Silt (%)	51.1	51.1
Sand (%)	8.7	8.7
EC (sc) (ds cm^{-1})	0.17	0.25
Bulk Density (Mg m^{-3})	1.43	1.47
Porosity (%)	45.95	46.1

RESULTS AND DISCUSSION

Ears plant^{-1}

Mean values of Table 1 shows that ears plant^{-1} was significantly affected by irrigation schedule and soil amendments. Maximum ears plant^{-1} (1.4) was recorded when 6 irrigations were applied while minimum ears plant^{-1} (1.1) was produced in plots having 3 irrigations. These results agree with Todorova (2000) who reported that (25%) reduction in ears plant^{-1} occur with decrease irrigations from 8 to 4 number this might have been due to abscission of pollen and poor pollination under moisture stress condition. Soil amendments had significant effect on number of ears plant^{-1}. Plots treated with FYM at the rate of 10 t ha^{-1} produced more ears plant^{-1} (1.5) while minimum ears plant^{-1} (1) was observed in control plots. Our result is also supported by Mwangi (2010) who reoported that FYM improved soil fertility by adding both major and essential nutrients as well as soil organic matters which improve moisture and nutrient retention as a result ears plant^{-1} improved as compared with control plots.

Grains ear^{-1}

Table 1 showed that number of grains ear^{-1} was significantly affected by irrigation and soil amendments. Crop grown in 2nd year produced maximum grains ear^{-1} (469) as compared with first year crop where grains ear^{-1} (455) was observed. The decomposition of FYM and crop residue applied during first year become available during 2nd year crop as a result more grains ear^{-1} in addition to more rainfall (42 %) in 2nd year as compared with first year crop. Plots supplied 6 irrigations produced more grains ear^{-1} (496) while minimum (427) number of grains ear^{-1} (427) was produced when plots received 3 irrigations. These results are in line with those of Giri et al. (2009) who reported 15% reduction in grains ear^{-1} with reducing irrigation from 8 to 4 numbers. Reduction in grains ear^{-1} might be due to water stress as a result shorter ear length and poor pollination as compared with on water stress. Soil amendments had significant effect on number of grains ear^{-1}. Plots treated with FYM at 10 t ha^{-1} produced more grains ear^{-1} (504), statistically at par when plots treated with humic acid, while minimum grains ear^{-1} (271) was observed in control plots. Our result are also supported by Singh et al., (2004) who reported that FYM improved soil fertility status by adding both major and miner nutrients as well as soil organic matters which improve moisture and nutrient holding capacity as a result grains ear^{-1} increased as compared with other soil amendments. Interaction between I x SA indicated by (Fig. 1) that under both irrigation conditions grains ear^{-1} increased significantly. Among soil amendments plots treated with FYM produced maximum grains ear^{-1} in both irrigation conditions as compared with other soil amendments. Linear increased in grains ear^{-1} was recorded when maize treated with 10 t FYM ha^{-1} and supplied six irrigations.

Shelling (%)

Data regarding shelling (%) given in Table 1 revealed that with increasing numbers of irrigation from three to six maximum shelling (72%) was recorded while minimum shelling (69%) was produced when plots received 3 irrigations. These results confirm the findings of Lafitte (1994) who reported that shelling (%) increased with increasing number of irrigation from 10 to 5 reductions in shelling (%) might be due to water stress during grain filling duration as a result shelling (%) decrease with decreasing number of irrigations. Soil amendments had significant effect on shelling (%). Plots treated with FYM at 10 t ha^{-1} produced more shelling (73%) while minimum shelling (62%) was recorded in control plots treatment of crop residue and humic acid were statistically at par. These results are supported by Rasool et al., (2005) who observed that FYM improved soil fertility status of soil by adding major and miner nutrients as well as soil organic matters which improve moisture and nutrient holding capacity as a result shelling (%) increased as compared with other soil amendments and control plots. Interaction between I x SA indicated by (Fig. 2) that under both irrigation conditions shelling % increased significantly. Among soil amendments plots treated with FYM produced maximum shelling % in both irrigation conditions as compared with other soil amendments. Linear increased in shelling % was recorded when maize treated with 10 t FYM ha^{-1} and supplied six irrigations.

Thousand grains weight (g)

Mean values of two years data revealed in Table 1 that thousand grains weight was significantly different in years, irrigation schedule and soil amendments. The interaction among I x SA and Y x I x SA was found significant. 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 in fact that 2nd year crop received 42 % more rainfall, organic matter increase from 1.50 to 2.04 g kg^{-1} and total nitrogen in soil is increase from 4.25 to 7.46 g kg^{-1} as compared with first year crop. Grains weight increased with increasing numbers of irrigation from three to six attained heavier grains weight (283.3 g) was recorded while minimum grains weight (258.5 g) was produced when supplied 3 irrigations. These results were given in line with those of Todorova (2000) who reported that significantly decreased in grains weight occur with decreasing number of irrigation from 8 to 4. Reductions of 15 to 30 % in grains weight might be due to water stress or drought at grain filling stage as compared with no stress. Soil amendments had 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 minimum 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. Figure 3 revealed that under both irrigation conditions thousand grain weight increased significantly. Among soil amendments plots treated with FYM produced maximum thousand grain weight as compared with other soil amendments. Linear increased in thousand grains weight was recorded when maize treated with 10 t FYM ha^{-1} and supplied six irrigations. Interaction among Y x SA x I indicated BY (Fig. 4) that in both years grains weight increased significantly when plots treated with FYM under both irrigation conditions as compared with other soil amendments. Linear increased in grains weight was recorded when maize treated with 10 t FYM ha^{-1} and supplied six irrigations, however sharply decreased in grains weight produced when plots treated with gypsum during both years and irrigation conditions.

Grain yield (kg ha^{-1})

Table 1 indicated that grain yield was significantly affected by years, irrigation schedule and soil amendments. The interaction between I x SA and Y x I x SA were found significant. Second year crop produced maximum grain yield (3817 kg ha^{-1}) as compared with first year produced grain yield (3555 kg ha^{-1}). The decomposition of FYM and crop residue applied during first year become available during 2^{nd} year crop as a result grain yield increased in addition to more rainfall (42 %), organic matter increase from 1.50 to 2.04 g kg^{-1} and total nitrogen in soil is increase from 4.25 to 7.46 g kg^{-1} in 2^{nd} year as compared with first year crop. Grain yield increased with increasing numbers of irrigation from three to six and produced maximum grain yield (3813 kg ha^{-1}) was recorded while minimum grain yield (3458 kg ha^{-1}) was produced when plots received 3 irrigations. These results agree with the findings of Giri et al. (2009) who reported that 6 number of irrigation increase grain yield (31.5%) when compared with half irrigated plots. It was due to the decrease in inter-plant competition and increase in grains ear^{-1} and ears $plant^{-1}$. 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 interaction between I x SA indicated by (Fig. 5) that irrigation had significantly increased grain yield as compared with control plots. Among soil amendments FYM produced maximum grain yield in both irrigation conditions as compared with other soil amendments. The three way interaction Y x SA x I for grain yield given (Fig. 6) revealed that during both years grain yield increased significantly with FYM under both irrigation conditions as compared with other soil amendments. Linear increased in grain yield was recorded when maize treated with FYM as soil amendment and supplied six irrigations during 2^{nd} year crop, however sharply decreased in grain yield produced when plots treated with gypsum under during both years and irrigation conditions.

Harvest index (%)

Harvest index present in Table 1 showed that irrigation schedule and soil amendments had significantly affected harvest index. Harvest index was significantly increased with increasing numbers of irrigation from three to six and produced maximum harvest index (27.3 %) was recorded while minimum harvest index (26.1 %) was produced when plots received 3 irrigations. Similar results were reported by Todorova (2000) who reported that 8 irrigations had increased harvest index (6%) when compared with 4 irrigations. It was due to the increase in number of irrigation which increased maize grain yield, photosynthesis capacity and reduced inter-plant competition as a result harvest index increased. Soil amendments had significant effect on harvest index. Plots treated with FYM had maximum harvest index (28.4 %) as compared with control (25.3 %). Increase in grain yield with FYM has been reported by Qian et al., (2004).

Table I. ***Ears plant^{-1}, grains ear^{-1}, shelling (%), thousand grains weight (g), grain yield (kg ha^{-1}) and harvest index (%) of maize as affected by year irrigation schedule and soil amendments during the two years experiments 2011 and 2012.***

Treatment	Ears plant^{-1}	Grains ear^{-1}	Shelling (%)	1000 grains weight (g)	Grain yie (kg ha^{-1})	H.I (%)
Year (Y)						
2011	1.2	455b	71	263.4b	3555b	26.1
2012	1.2	469a	72	278.2a	3817a	26.3
Irrigation Schedule (I)						
6	1.4a	496a	72a	283.3a	3813a	27.3a
3	1.1b	427b	69b	258.5b	3458b	26.1b
Soil Amendments (SA)						
Control	1.0e	271d	62d	164.1d	2413d	25.3d
Farm Yard manure	1.5a	504a	73a	287.4a	3896a	28.4a
Crop Residue (CR)	1.2c	460b	72b	271.2b	3704b	27.2b
Gypsum (GYP)	1.1d	445c	71c	248.3c	3618c	26.3c
Qemisoyl (QEM)	1.2c	430c	71c	263.1b	3624c	27.1b
Humic acid (HA)	1.3b	483a	72b	278.5a	3833a	27.3b
LSD (0.05)	0.005	24	0.64	14	76	0.97
Interaction						
Y x I	ns	ns	ns	ns	ns	ns
Y x SA	ns	ns	ns	ns	ns	ns
I x SA	ns	*	*	*	*	ns
Y x I x SA	ns	ns	ns	*	*	ns

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

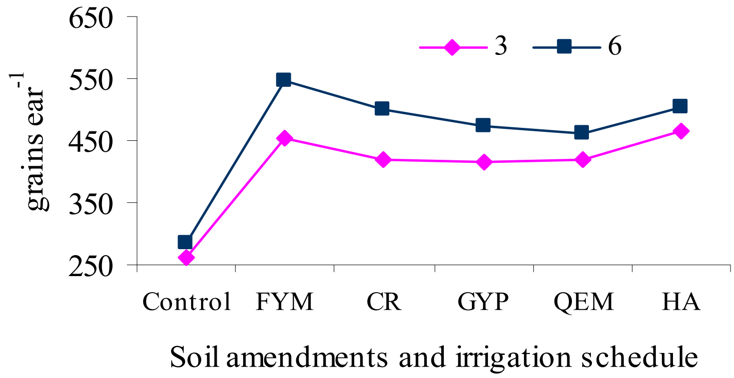

Fig. 1. Grains ear^{-1} of maize as affected by soil amendments and irrigation schedule.

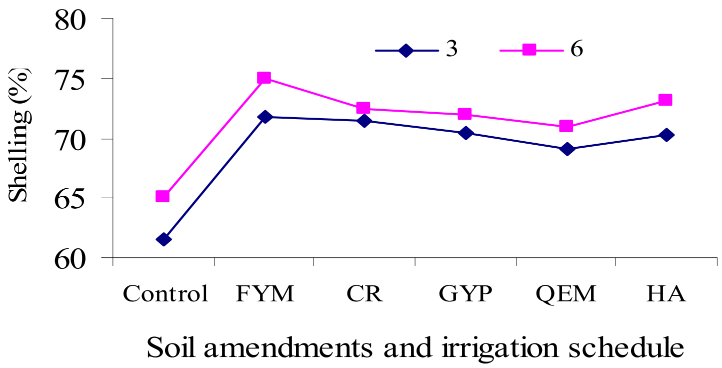

Fig. 2. Shelling (%) of maize as affected by soil amendments and irrigation schedule.

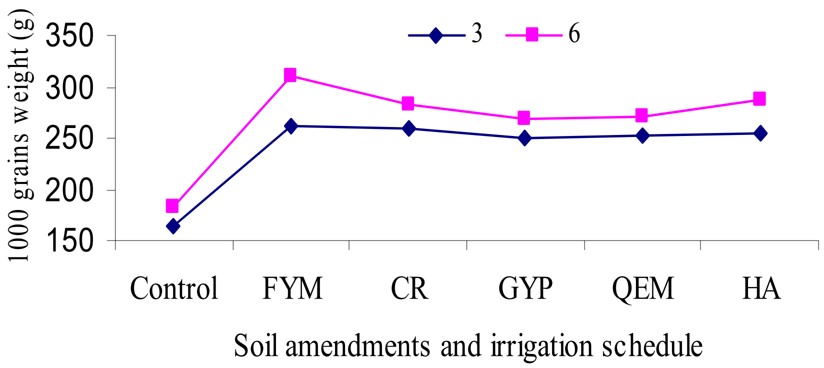

Fig. 3. Thousand grains weight of maize as affected by soil amendments and irrigation schedule.

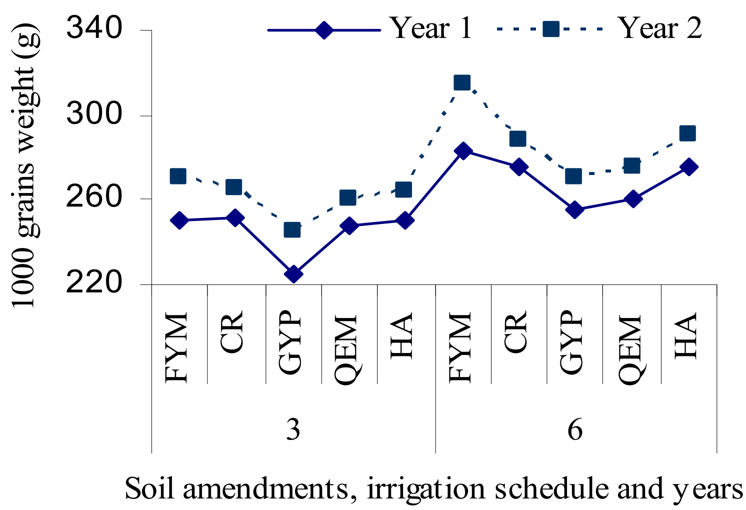

Fig. 4. Thousand grains weight of maize as affected by irrigation schedule and soil amendments during 2011-12.

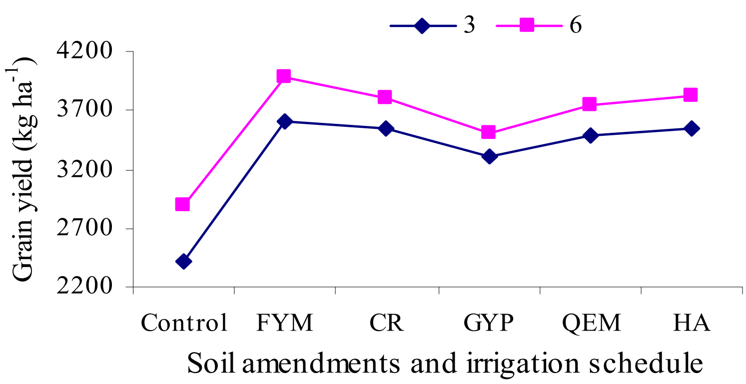

Fig. 5. Grain yield of maize as affected by soil amendments and irrigation schedule.

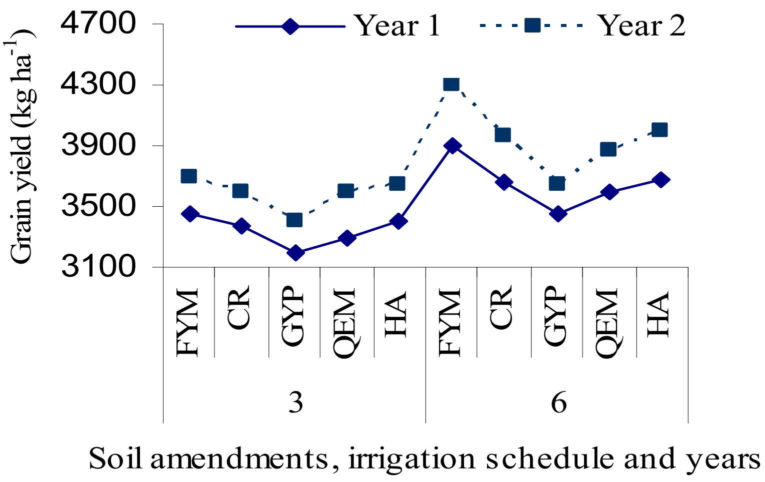

Fig. 6. Grain yield of maize as affected by irrigation schedule and soil amendments during 2011-12.

CONCLUSION AND RECOMMENDATIONS

Both FYM and humic acid had improved the yield and yield component of maize as compared to control plots. Plots received six irrigations performed better than three irrigations. Maize yield can be increased by application of FYM at 10 tons ha^{-1} or humic acid at (12 kg ha^{-1}) having six irrigations is recommended for improving yield and yield components of maize under similar soil and climatic conditions.

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