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Phosphorus and Tillage Management for Maize under Irrigated and Dryland Conditions

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Abstract: Deficiencies of phosphorous (P) and soil moisture are the main limiting factors under semiarid climates throughout the world. Proper tillage management could increase P and water availability and therefore crop productivity under semiaraid climates. The objective of this study was to investigate proper P and tillage management practices for improving growth, yield and yield components of maize (*Zea mays* L. cv Azam). The experiment was conducted under, irrigated (no moisture stress) and dryland (moisture stress) conditions at the Agronomy Research Farm of The University of Agriculture, Peshawar Pakistan during summer 2012. Experiment was laid out in randomized complete block design with split-plot arrangement having three replications under both irrigated and dryland conditions. Tillage depths (15, 30 and 45 cm) were assigned to main-plots while P levels (0, 30, 60 and 90 kg ha^{-1}) allotted to sub-plots. Better growth and higher yield components and grain yield (3535 kg ha^{-1}) was obtained when P was applied at the highest rate of 90 kg P ha^{-1} (90 > 60 > 30 > 0 kg P ha^{-1}). Increase in tillage depths showed positive relationship with grain yield and yield components. The deep tillage depth (45 cm) produced the highest grain yield (3323 kg ha^{-1}) while the shallow depth (15 cm) resulted in the lowest grain yield (2894 kg ha^{-1}). Maize planted under irrigated condition had better growth, higher yield components and therefore resulted in the higher grain yield (3621 kg ha^{-1}) as compared with maize under dryland (water stress) condition. We concluded from this study that increase in P level and tillage depth had positive effect on growth, yield components and grain yield of maize under both irrigated and dryland conditions.

Key words: Zea mays; tillage depths; irrigation; phenology; growth; yield; semiarid climate

Introduction

Maize (*Zea mays* L.), a member of family Poaceae and one of the top three cereals grown in the world along with rice (*Oryza sativa*) and wheat (*Triticum* spp.). Maize is the second most important crop after wheat in the Khyber Pakhtunkhwa but its yield unit^{-1} area is very low Amanullah *et al.,* (2012). In the period 2013-2014, Maize was grown on an area of 1,117 thousand hectares with production of 4527 thousand tons and average yield of 4,053 kg ha^{-1} while in Northwest Pakistan (Khyber Pakhtunkhwa), area under maize cultivation is 440.60 thousand hectares with production of 833.56 thousand tons and average yield of 1892 kg ha^{-1} MINFAL (2013). It is also grown in winter and play an important role in production of livestock, where feed stuffs is not sufficient for animal requirements such as in tropical zone because of less fertility of soil, drought Eltelib *et al.,* (2006).

Phosphorus (P) being one of the most required elements in plant life and the numbers of available p in the soil is always inadequate to meet requirement of plants. Phosphorus is a macronutrient and performs very important activities in plants. Proper amount of phosphorus results in higher grain production, improved crop quality, greater stalk strength, increased root growth, and earlier crop maturity Mokwunye *et al.,* (1986). Phosphorus is immobile in soil therefore its unavailability is affecting growth of plants in addition to its low levels in our soils. Rashid (2001) revealed that more than 90% of Pakistani soils are deficient in phosphorus. In phosphorus deficient situation become worst in dry land condition where there is always shortage of moisture that effect fertilizer efficiency and successful crop production. Raj *et al.,* (1999) concluded that the unavailability of phosphorus in soil is one of the factors affecting biomass and grain yield of mungbean under moisture stress conditions. Phosphate fertilizer absorption behaviors depend upon the method and levels of application. Pannu and Sawhney (1975) reported that placement of phosphorus at the depth of 10–15 cm increased yield by 35% over broadcasted application. The fertilizer utilization efficiency may be enhanced by application methods such as placement because this minimizes the period of time in which fertilizer is subjected to loss (Fox et al., 1986; Warren, 1992) stated that phosphorus deficiency is one of the major constraints to food production in tropical African soils due to low native P and high fixation by iron and aluminum oxides. Proper tillage management and application of fertilizer according to crop needs enhances yield of crops. Phosphorus is hardly available to plants in the early stages of growth because of soil cold temperature which restrict P movement to plant roots Alley *et al.,* (2009).

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Mechanical manipulation of soil is called Tillage. These practices are done in order to prepare fine seed bed for sowing, soil physical structures are improved and help in weeds control. Tillage is considered the most effective farm activity for the purpose of developing a preferred soil structure. It increases the physical conditions of soil and favors the rooting characteristics of plants (Amanullah et al., 2015; Amanullah et al., 2014). Tillage operations and fertility management often effect soil properties, nutrient availability, and crop yields. Tillage is one of the vital factors that influence soil properties and crop yields Islam *et al.,* (2000). Khurshid *et al.,* (2006) reported that tillage contributes up to 20% of the crop production factors. The type and intensity of plowing affects the agricultural sustainability through its influence on soil properties McGarry et al., 2000; Sundermeier et al., 2011.

Many environmental, cultural and genetic factors influence maize yield and quality Çarpıcı *et al.,* (2010). Maize producers require more information on how different water supply regimes affect grain yield, dry matter yield and yield components like plant height, ear weight and 1000 kernels weight. Igbadun *et al.,* (2008) reported that deficit irrigation at any crop growth stage of the maize crop led to decrease in dry matter and grain yields, seasonal evapotranspiration, deep Percolation. Cakir, 2004 reported that the maximum grain yields were obtained in the fully irrigated and the treatment which allowed water stress during the vegetative growth stage. Many researchers have assessed the effect of drought and irrigation on maize yield and yield components Karam et al., 2003; Payero et al., 2006; Igbadun *et al.,* 2008.

For efficient utilization of nutrients and water and for enhancing soil organic matter many researchers in Pakistan now advise the farmers to follow the principle of conservation agriculture in rainfed area. However, there is very little scientific information available as to how the crop residues and no-tillage practices will affect N fixation and water use efficiency. Keeping in view the importance of phosphorus levels, tillage depths and water availability, therefore the current experiment was designed to investigate the influence of different P levels and tillage depths for improving growth of maize under irrigated and un-irrigated conditions.

Materials and Methods

To investigate the effect of P levels (0, 30, 60 and 90 kg ha^{-1}) and tillage depths (15, 30 and 45 cm) on phenology, growth yield and yield components of maize (*Zea mays* L., cv. Azam) an experiment was conducted under semiarid climate at the Agronomy Research Farm of The University of Agricultural Peshawar, during summer 2012. Two separate experiments were conducted under irrigated and un-irrigated conditions. Each experiment was laid out in randomized complete block design with split-plot arrangements using three replications. Tillage depths (15, 30 and 45 cm) were assigned to main plot and four P levels (0, 30, 60 and 90 kg ha^{-1}) to sub-plots. Each replication consisted of 12 treatments. A sub-plot size of 5 m by 4 m, having 10 rows (4 m long and 50 cm) apart was used. Tillage implements chisel plough; mould board plough and cultivator were used for 15, 30 and 45 cm deep tillage respectively. A uniform basal dose of 120 kg N ha^{-1} as urea was be applied and mixed with the soil during seedbed preparation to all plots. Phosphorus in the form of single super phosphate (18 % P_2O_5) was applied at the time of sowing. In irrigated experiment, irrigations were applied according to the crop need. However, under un-irrigated experiment, one irrigation was applied for seedbed preparation only and the crop completed its life cycle with rainfall water (Table 1). Data were recorded on days to physiological maturity, plant height, leaf area plant^{-1}, leaf area index, leaf dry weight plant^{-1}, stem dry weight plant^{-1} (g), ear dry weight plant^{-1} (g), Total dry weight plant^{-1} (g), grain ear^{-1}, 1000 grains weight, Stover yield, biological yield (kg ha^{-1}), grain yield (kg ha^{-1}) and harvest index. Data were subjected to analysis of variance (ANOVA) according to the methods described by Steel *et al.,* (1997) and means between treatments was compared by least significant difference ($P \leq 0.05$).

Results

Days to physiological maturity

Days to physiological maturity was significantly affected by irrigation and phosphorus levels, while tillage depths had no significant effects on days to Physiological maturity (Table 2). The mean values of the plots without irrigation matured earlier (87 days) than the plots with irrigation (88 days). Days to physiological maturity showed negative relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) matured earlier (86 days), followed by 87 days each with 30 and 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) had the delayed physiological maturity (89 days).

Table 1: Temperature (C°), rainfall (mm) and relative humidity (%) of the experimental site for the growing period of maize crop (June-October 2012)

Month	Mean Temperature (C°)		Mean Rainfall (mm)	Relative Humidity (%)
	Minimum	Maximum		
June	22	43	0	35
July	27	41	100	56
August	26	38	100	59
September	23	35	110	70
October	15	31	100	56

Table 2: Days to physiological maturity, plant height (cm), leaf area plant^{-1} (cm^2) and leaf area index as affected by tillage system and phosphorous levels under irrigated and un-irrigated conditions

Phosphorous levels (kg P ha^{-1})	Day to physiological maturity	Plant height (cm)	Leaf area plant^{-1} (cm^2)	Leaf area index
0	89	178	3449	2.76
30	87	203	3963	3.17
60	87	210	4129	3.3
90	86	213	4286	3.43
Significance	**	**	**	**
Tillage depth (cm)				
15	87	189	3725	2.98
30	87	205	4038	3.23
45	87	213	4106	3.29
Significance	ns	**	**	**
Irrigation				
Irrigated	88	209	4183	3.35
Un-irrigated	87	196	3730	2.98
Significance	**	*	**	**
Interactions				
T x I	ns	ns	ns	ns
P x T x I	ns	ns	ns	ns

Where:

T = tillage depths, I = irrigation and P = phosphorus

* stands for significant at P ≤ 0.05, ** stands for significant at P ≤ 0.01, and ns stands for non-significant data at P ≤ 0.05

Table 3: Leaf dry weight plant^{-1}, stem dry weight plant^{-1}, ear dry weight plant^{-1} and total dry weight plant^{-1}as affected by tillage system and phosphorous levels under irrigated and un-irrigated conditions

Phosphorous Levels (kg P ha^{-1})	Leaf dry weight (g plant^{-1})	Stem dry weight (g plant^{-1})	Ear dry weight (g plant^{-1})	Total dry weight (g plant^{-1})
0	36.39	87.33	122.07	245.79
30	43.28	109.65	157.69	309.62
60	46.75	116.83	166.21	329.79
90	49.67	126.58	179.29	335.54
Significance	**	**	**	**
Tillage depths (cm)				
15	41.54	106.57	153.72	301.83
30	43.98	109.71	153.26	307.01
45	45.79	113.96	161.96	321.71
Significance	*	*	*	*
Irrigation				
Irrigated	47.14	118.83	168.15	334.13
Un-irrigated	40.4	101.37	144.48	286.25
Significance	**	**	**	**
Interactions				
T x I	ns	ns	ns	ns
P x T x I	ns	ns	ns	ns

Where:

T = tillage depths, I = irrigation and P = phosphorus* stands for significant at P ≤ 0.05, ** stands for significant at P ≤ 0.01, and ns stands for non-significant data at P ≤ 0.05

Table 4: Grains ear^{-1}, 1000 grains weight, stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) grain yield (kg ha^{-1}) and harvest index as affected by tillage systems and phosphorous levels under irrigated and un-irrigated conditions

Phosphorous (kg P ha^{-1})	Number of grains ear^{-1}	1000 grains weight (g)	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
0	306	219	6552	9059	2507	27.7
30	384	228.94	7292	10385	3093	29.6
60	390	230.94	7511	10772	3261	30.3
90	397	232.78	7369	10904	3535	32.3
Significance	**	**	ns	*	**	**
Tillage depths (cm)						
15	359	224.29	7020	9913	2894	29.1
30	372	228.13	7222	10303	3081	29.6
45	376	231.33	7301	10624	3323	31.2
Significance	**	*	ns	*	**	**
Irrigation						
Irrigated	399	231.67	7873	11494	3621	31.5
Un-irrigated	340	224.17	6489	9066	2577	28.5
Significance	**	**	**	**	**	**
Interactions						
T x I	ns	ns	ns	ns	ns	ns
P x T x I	ns	ns	ns	ns	ns	ns

Where:
T = tillage depths, I = irrigation and P = phosphorus
*stands for significant at $P \leq 0.05$, ** stands for significant at $P \leq 0.01$, and ns stands for non-significant data at $P \leq 0.05$.

Plant height

Plant height (cm) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 2). The mean values of the plots with irrigation produced taller plants (209 cm) than the plots without irrigation (196 cm). Plant height showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in tallest plants (213 cm), followed by 30 cm tillage depth (205 cm), whereas the shortest plants of 189 cm heights were obtained with shallow tillage depths (15 cm). Plant height showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced tallest plants (219 cm), followed by 210 cm with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the shortest plants (178 cm).

Leaf area plant^{-1}

Leaf area plant^{-1} (cm^2) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 2). The mean values of the plots with irrigation produced more leaf area plant^{-1} (cm^2) (4183 cm^2) than the plots without irrigation (3730 cm^2). The leaf area plant^{-1} (cm^2) showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest leaf area plant^{-1} (4106 cm^2), followed by 30 cm tillage depth (4038 cm^2), whereas the lowest leaf area plant^{-1} (3725 cm^2) was obtained with shallow tillage depths (15 cm). The leaf area plant^{-1} (cm^2) showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest leaf area plant^{-1} (4286 cm^2), followed by 4129 cm^2 with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest leaf area plant^{-1} (3449 cm^2).

Leaf area index

Leaf area index (LAI) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 2). The mean values of the plots with irrigation produced more LAI (3.35) than the plots without irrigation (2.98). The LAPP showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest LAI (3.29), followed by 30 cm tillage depth (3.23), whereas the lowest LAI (2.98) was obtained with shallow tillage depths (15 cm). The LAI showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest LAI (3.43), followed by 3.30 with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest LAI (2.76).

Leaf dry weight plant^{-1}

Leaf dry weight per plant (LDWPP) (g) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 3). The mean values of the plots with irrigation produced more LDWPP (47.14 g) than the plots without irrigation (40.40 g). The LDWPP showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest LDWPP (45.79 g), followed by 30 cm tillage depth (43.98 g), whereas the lowest LDWPP (41.54 g) was obtained with shallow tillage depths (15 cm). The LDWPP showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest LDWPP (49.67 g), followed by 46.75 g with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest LDWPP (36.39 g).

Stem dry weight plant^{-1}

Stem dry weight plant^{-1} (SDWPP) (g) in maize was significantly affected by irrigation, tillage depths and phosphorus levels while all the interactions were found non-significant (Table 3). The mean values of the plots with irrigation produced more SDWPP (118.83 g) than the plots without irrigation (101.37 g). The SDWPP showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest SDWPP (113.96 g), followed by 30 cm tillage depth (109.77 g), whereas the lowest SDWPP (106.57 g) was obtained with shallow tillage depths (15 cm). The SDWPP showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest SDWPP (126.58 g), followed by 116.83 g with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest SDWPP (87.33g).

Ear dry weight plant^{-1}

Ear dry weight plant^{-1} (EDWPP) (g) in maize was significantly affected by irrigation, tillage depths and phosphorus levels while all the interactions were found non-significant (Table 3). The mean values of the plots with irrigation produced more EDWPP (168.15 g) than the plots without irrigation (144.48 g). The EDWPP showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest EDWPP (161.96 g), followed by 15 cm tillage depth (153.72 g) being at par with EDWPP of 153.26 g was obtained with shallow tillage depths (15 cm). The EDWPP showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest EDWPP (179.29 g), followed by 166.21 g with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest EDWPP (122.07 g).

Total dry weight plant^{-1}

Total dry weight plant^{-1} (TDWPP) (g) in maize was significantly affected by irrigation, tillage depths and phosphorus levels while all the interactions were found non-significant (Table 3). The mean values of the plots with irrigation produced more TDWPP (334.13 g) than the plots without irrigation (286.25 g). The TDWPP showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest TDWPP (321.71 g), followed by 30 cm tillage depth (307.01 g), whereas the lowest TDWPP (301.84 g) was obtained with shallow tillage depths (15 cm). The TDWPP showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest TDWPP (355.54 g), followed by 329.79 g with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest TDWPP (245.79 g).

Number of grains ear^{-1}

Number of grains ear^{-1} (NGPE) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 4). The mean values of the plots with irrigation produced more NGPE (399) than the plots without irrigation (340). The NGPE showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest NGPE (376), followed by 30 cm tillage depth (372), whereas the lowest NGPE (359) was obtained with shallow tillage depths (15 cm). The NGPE showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest NGPE (397), followed by 390 with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest NGPE (306).

Thousand grains weight

Thousand grains weight (TGW) (g) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 4). The mean values of the plots with irrigation produced more TGW (231.67 g) than the plots without irrigation (224.17 g). The TGW showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest TGW (231.33 g), followed by 30 cm tillage depth (228.29 g), whereas the lowest TGW (224.29 g) was obtained with shallow tillage depths (15 cm). The TGW showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest TGW (232.78 g), followed by 230.94 g with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest TGW (219.00 g).

Stover yield

Stover yield (kg ha^{-1}) in maize was significantly affected by irrigation, tillage depths and phosphorus levels while all the interactions were found non-significant (Table 4). The mean values of the plots with irrigation produced more stover yield (7873 kg ha^{-1}) than the plots without irrigation (6479 kg ha^{-1}). The stover yield showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest stover yield (7301 kg ha^{-1}), followed by 30 cm tillage depth (7222 kg ha^{-1}), whereas the lowest stover yield (7020 kg ha^{-1}) was obtained with shallow tillage depths (15 cm). The stover yield showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest stover yield (7369 kg ha^{-1}), being at par with 7511 kg ha^{-1} at 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest stover yield (6572 kg ha^{-1}).

Biological yield

Biological yield (kg ha^{-1}) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 4). The mean values of the plots with irrigation produced more biological yield (11494 kg ha^{-1}) than the plots without irrigation (9066 kg ha^{-1}). The biological yield showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest biological yield (10624 kg ha^{-1}), followed by 30 cm tillage depth (10303 kg ha^{-1}), whereas the lowest biological yield (9913 kg ha^{-1}) was obtained with shallow tillage depths (15 cm). The biological yield showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest biological yield (10904 kg ha^{-1}), followed by 10772 kg $ha^{-1}$with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest biological yield (9059 kg ha^{-1}).

Grain yield

Grain yield (kg ha^{-1}) in maize was significantly affected by irrigation, tillage depths and phosphorus levels (Table 4). The mean values of the plots with irrigation produced more grain yield (3621 kg ha^{-1}) than the plots without irrigation (2577 kg ha^{-1}). The grain yield showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest grain yields (3323 kg ha^{-1}), followed by 30 cm tillage depth (3081 kg ha^{-1}), and whereas the lowest grain yields (2894 kg ha^{-1}) was obtained with shallow tillage depths (15 cm). The grain yield showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest grain yield (3535 kg ha^{-1}), followed by 3261 kg $ha^{-1}$with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest grain yield (2507 kg ha^{-1}).

Harvest index

Harvest index (%) in maize was significantly affected by irrigation, tillage depths and phosphorus levels while all the interactions were found non-significant (Table 4). The mean values of the plots with irrigation produced more harvest index (31.5 %) than the plots without irrigation (28.5 %). The harvest index showed positive relationship with increase in tillage depths. The maximum tillage depths (45 cm) resulted in highest harvest index (31.2 %), followed by 30 cm tillage depth (29.6 %), whereas the lowest harvest index (29.1 %) was obtained with shallow tillage depths (15 cm). The harvest index showed positive relationship with increase in P levels. The mean values of the plots with the highest P level (90 kg ha^{-1}) produced highest harvest index (32.3 %), followed by 30.3 % with 60 kg P ha^{-1}, whereas the control (0 kg P ha^{-1}) produced the lowest harvest index (27.7 %).

Discussion

Days to maturity was delayed with application of irrigation. This might be due to the vigorous growth of plants with the application of water which increases nutrients uptake and more photosynthesis increases vegetative growth and hence delayed the plants to reach reproductive stage. These results corroborate the findings of Khan *et al.,* (2001) who reported that days to accomplish flowering decreased significantly with increasing water stress. Mubeen *et al.,* (2013) reported that Irrigation levels showed a linear response to get maturity. Plant height of maize was significantly affected by irrigation. This might be due to sufficient availability of nutrients having no moisture stress and vigorous vegetative growth. Similar results were reported by Khaliq *et al.,* (2009). Mubeen *et al.,* (2013) revealed that lowest plant height was found when minimum irrigation was applied to maize crop. Meskelu *et al.,* (2014) showed that plant height associated with the water applied at development stage. Promotion effect of high P level on plant height was probably due to better development of root system and nutrient absorption Hussain *et al.,* (2006). Arain *et al.,* (1989); Masood *et al.,* (2011) reported that plant height of maize increased with increase in P application. Data regarding leaf area and leaf area index of maize was significantly affected by irrigation. This might be due to more assimilates production in the process of photosynthesis. Cakir, 2004 reported more leaf area when there is no water stress.

Data regarding number of grains ear^{-1} of maize showed that number of grains $ear^{-1}$was significantly affected by irrigation. This might be due to lack of water in the soil profile at critical tasselling and ear formation stages dramatically decreased the grain set on the ear. Setter *et al.,* (2001) evaluated that water deficit substantially increased ABA concentrations in all reproductive tissues of corn. They suggested that ABA may play a role in the loss of grain set within apical regions of an ear in response to water deficit. Arain *et al.,* (1989); Masood *et al.,* (2011) reported that number of grains ear^{-1} of maize increased with increase in P application. Thousand grains weight of maize was significantly affected by irrigation. This might be due to more translocation of photosynthates towards grains by sufficient availability of water present in the root zone. These results are same with the finding of Meskelu *et al.,* (2014) who reported that moisture stress at different maize growth stage had a significant influence on thousand grains weight. Hussain *et al.,* (2006); Masood *et al.,* (2011) observed an increase in 1000-grains weight with increase in NP application. Phosphorus being responsible for good root growth directly affected the thousand grains weight because P at the rate of 0 kg ha^{-1} (control plots) resulted in the least thousand grains weight Hussain *et al.,* (2006).

Data regarding biological yield of maize revealed that biological yield was significantly affected by irrigation. This might be due to more biomass production by maize plant due to no stress and the plant uptake water and nutrients efficiently. Biomass production shows decreasing with increasing of moisture stress indicating well irrigated maize yields higher biomass production. This is in agreement with former reports of Ersel *et al.,* (2010) on maize. Meskelu *et al.,* (2014) showed positive response of biological yield to water stress. The present study results are in line with that of Diaz-Zorita *et al.,* (2000) that maize production enhanced with increasing tillage practices. Masood *et al.,* (2011) reported that 100 kg P ha^{-1} resulted in best biological yield due to efficient photosynthesis and other physiological functions at this P level. That's why the biological yield was the lowest in the control plots. Grain yield was significantly increased with irrigation. The reason might be that with more irrigation water, plants took more nutrients through roots which enhanced dry matter of the plants. With bigger canopy plants prepared more starch for transfer to the seeds which ultimately increased grain yield. Kuscu and Demir, 2013 reported that grain yield was smaller with limited irrigation water. Payero et al., 2006 reported linear increase in grain yield of maize due to increase in irrigation levels. Ramzan and Khattak, 1995 found that deep tillage were too much effective in losing the soil resulting in proper moisture conservation, lower bulk density, lower soil strength, reduce weeds, fresh weed biomass, thousand grain weight and maximum grain yield. Hussain *et al.,* (2006); Masood *et al.,* (2011) who found that grain yield increased with phosphorus application and plots receiving 90 kg P ha^{-1} gave maximum grain yield as compared to lower dose grain yield. Data regarding harvest index of maize revealed that harvest index was significantly affected by irrigation. This might be due to more production of plants with no water stress. Meskelu *et al.,* (2014) revealed that when moisture stress happens at growth stages affect the grain yield than the biomass which reduces the harvest index. Our recent similar research work (Amanullah *et al.,* 2016) on mungbean (*Vigna radiata* L., Wilczek) revelaed that application of 90 kg P ha^{-1} and shallow tillage (15 cm) was more beneficial for improving growth, yield and yield components of mungbean under irrigated condition (no moisture stress); under dryland condition (with moisture stress), application of 90 kg P ha^{-1} and deep tillage (45 cm) was found better for improving growth, yield and yield components of mungbean. According to Amanullah et al. (2015), mungbean varities differ in their response to different tillage management practices.

Conclusion

We concluded from this study that increase in P level and tillage depth had positive effect on growth, yield components and grain yield of maize under both irrigated (no moisture stress) and un-irrigated (moisture stress) conditions under semiarid climates.

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