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PERFORMANCE AND ECONOMICS OF GROWING MAIZE UNDER ORGANIC AND INORGANIC FERTILIZATION AND WEED MANAGEMENT

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Abstract

Weed competition and imbalanced fertilizers are important yield reducing factors in maize. To investigate the impact of weed management and combinations of fertilizers on yield and net income of maize, a field trial was conducted at National Agricultural Research Centre, Islamabad, Pakistan during summer 2014. Randomized complete block design with split-plot arrangement was used with three replications. Four weeds pressures viz. (1) hand weeding at 25 cm on both sides of each row of maize plants, (2) No hand weeding at 25 cm on both sides of maize rows, (3) application of Primextra gold (atrazine plus S-metolachlor) @ 1.44 kg a.i. ha^{-1} as pre-emergence and (4) weedy check (control) were assigned to main plots. While different combinations of NPK were assigned to sub plots. Data revealed that dry weed biomass close to maize plants were significantly lower (140.4 kg ha^{-1}) as compared to weeds 25 cm away from maize plants (153.2 kg ha^{-1}). However, the application of atrazine plus S-metolachlor showed promising results by decreasing the weed biomass (53.6 kg ha^{-1}) as compared to 155.6 kg ha^{-1} in control. Combination of fertilizers, also significantly affected the weed biomass. As compared to control, all the fertilizers (N, P and K) significantly increased weed biomass. Presence of weeds close to the crop rows, proved more harmful for grain yield of maize. Overall, application of herbicide in combination with NPK showed promising results in term of weed control and grain yield. Net income was higher when herbicide in combination with N, P or NP was used.

Key words: Fertilizers, Maize, Net income, Weeds, Weeding distance.

Introduction

Maize (*Zea mays* L.) is cultivated in spring and summer for grain as well as for fodder purpose in developing countries. Therefore the demand for maize is increasing due to increase in human population and growing livestock industry. In addition to these, oil industries are also interested in bringing more area under maize cultivation. Being short duration crop, the farmers prefer to grow maize for getting higher income. Due to unlimited uses and high production potential, maize plays an important role in economies of many countries including Pakistan. Maize can be grown successfully under different climatic conditions but low humidity and high temperature affect pollination and thus decrease yield (Hashim *et al*., 2013). Weed infestation (Saeed *et al.,* 2010), imbalanced fertilizers (Khan *et al*., 2013) and several other factors (Rashid *et al*., 2008) severely affect the maize production. Balanced dose of macro and micro nutrients play a vital role in increasing yield. Therefore nutritional requirements need to be studied (Asghar *et al*., 2010). Maize is an exhaustive crop and thus uses the nutrients at all the stages of its growth. Among the essential nutrients, nitrogen (N) play a vital role in overall production (Ding *et al*., 2005; Santos *et al*., 2015) as it is linked with dark green color of vegetative parts, branching and leaf production that significantly increase dry biomass (Rashidi *et al*., 2015). Phosphorus (P) is considered to be the second important nutrient, as P influences the growth and yield related traits of plants that is ultimately allocated to the embryo to improve seed vigor (Seyyedi *et al*., 2015). P deficiency is widespread in 90% of the Pakistani soils (Rashid & Memon, 2001) and thus needs to be applied to all the crops. Like inorganic fertilizers, farmyard manure (FYM) contains all the nutrients, and thus provide a balanced nutrition to plants (Achieng *et al.,* 2010). FYM persists for longer period of time therefore it may become a major need for crops (Swift *et al*., 1994) but is slowly available to the plants (Das, 2005). However, the use of FYM for maize is not common in our country.

Among biotic factors, weed infestation is a serious challenge for maize growers in our country. To manage the weeds in maize, time of weed emergence and distance from crop plants is helpful in estimating the yield loss (Swanton *et al*., 2015). The reduction in crop yield due to weeds is 20-40% however, in areas of higher densities and more competitive weeds species, these losses could be greater (Waheedullah *et al*., 2008). Weed control using physical methods are difficult due to hot weather in summer season. However, farmers having large area under maize, use herbicides. But the small farmers either ignore weeds or control at later stages of the weeds in developing countries. Although yield reduction due to presence of weeds and absence of fertilizer is well understood, but the weeding distance and combination of N, P and K under different weeds pressure is little understood. Therefore, the present study was conducted to investigate the performance of maize and the net income under different combinations of fertilizers and weed pressure under irrigated conditions.

Materials and Methods

Experimental site: A field trial was conducted at National Agricultural Research Center, Islamabad, Pakistan (73.04^{0}E and 33.43^{0}N. This area has a humid sub-tropical climate with an annual rainfall of 517 to 1550 mm. More than half rain is received in the form of high intensity down-pours during July and August. Mean maximum temperature during summer ranges from 36 to 42°C. Soil is alkaline (pH, 7.8) coarse loamy, calcareous ($CaCO_3$ equiv., 4.3 g/100g), low in organic matter (0.50 g/100g), and deficient in NO_3-nitrogen (3.5 mg kg^{-1}), phosphorus (3.0 mg kg^{-1}), potassium (80 mg kg^{-1}) and Zinc is around 0.27 mg kg^{-1} (Anon., 2006). The site is mainly used for experimentation purpose with some crops for commercial purpose.

Plant materials: Good quality seed of maize (*Zea mays* L.), cultivar 'Azam' was obtained from the Agricultural Research Farm, The University of Agriculture Peshawar, Pakistan. This cultivar was selected due to its wide cultivation in the maize growing belts of the country.

Experimental design: Well leveled field was selected for the study by giving a soaking irrigation and then seed bed was prepared at suitable moisture conditions, by cultivating the soil three times with the tractor mounted cultivator followed by planking to make it flat. The seeds were planted by using dibbling method and thinning was done where necessary, to maintain constant plant population of maize (75,000 seeds ha^{-1}) where row to row and plant to plant distance was 70 and 20 cm, respectively. A randomized complete block design with split-plot arrangement was used with three replications. Four weeds pressures viz. (1) hand weeding at 25 cm on both sides of each row of maize plants (Fig. 1), (2) no hand weeding at 25 cm on both sides of each row of maize plants (Fig. 1), (3) application of Primextra gold (atrazine + S-metolachlor) @ 1.44 kg a.i. ha^{-1}) as pre-emergence and (4) weedy check (control) were assigned to main plots. While nine treatments viz. N, P, K, NP, NK, PK, NPK, FYM and control (no fertilizer) were assigned to sub plots. N, P, and K were applied at recommended doses (120, 90, 60 Kg ha^{-1}), respectively and FYM at 20 tons ha^{-1}. The sources of the N, P and K were Urea, DAP and Potash, respectively. All the fertilizers were applied in whole doses except N that was applied in two split doses i.e. half during sowing and the remaining half was applied when maize plant reached at height of 50 cm. All the fertilizers were broadcasted and mixed with the soil. All the required agronomic standard practices were used before and after the crop emergence. Experimental field was five times irrigated at suitable times, keeping in mind the crop requirement for irrigation throughout the course of the trial. The maize crop was harvested manually at physiological maturity in October, 2014.

Procedure for data recording: To record dry weed biomass (40 days after crop sowing), five quadrates (50 x 50 cm) were randomly placed in each experimental unit and the weeds inside the quadrate were identified, collected and placed in labeled paper bags. The weeds samples were dried in an oven for about 70 ± 2^{o}C for 48 hours at NARC, Islamabad. For recording plant height of maize, ten plants were randomly selected from each treatment and height was measured from ground level to the tip of the plant. Similarly, 1000 kernel weight was recorded by taking the required quantity from each sub plot and weight was determined. The cobs were randomly selected from ten plants in each sub plot and were threshed and counted separately that were subsequently averaged.

For biological yield, two central rows were harvested at maturity, sun dried and weight was recorded and subsequently converted into kg ha^{-1}. The cobs of the harvested plants were cleaned and threshed after drying and subsequently the grain yield was recorded at 15% moisture content. To compare the net income, the total expenditure and total income was recorded for each experimental unit in Pakistani Rupees (PKRs).

Statistical analysis: The data recorded for different parameters were subjected to statistical analysis using "Statistix 8.1" package for Analysis of Variance (ANOVA) and Least Significant Difference (LSD) test were used for mean separation (Steel *et al*., 1997).

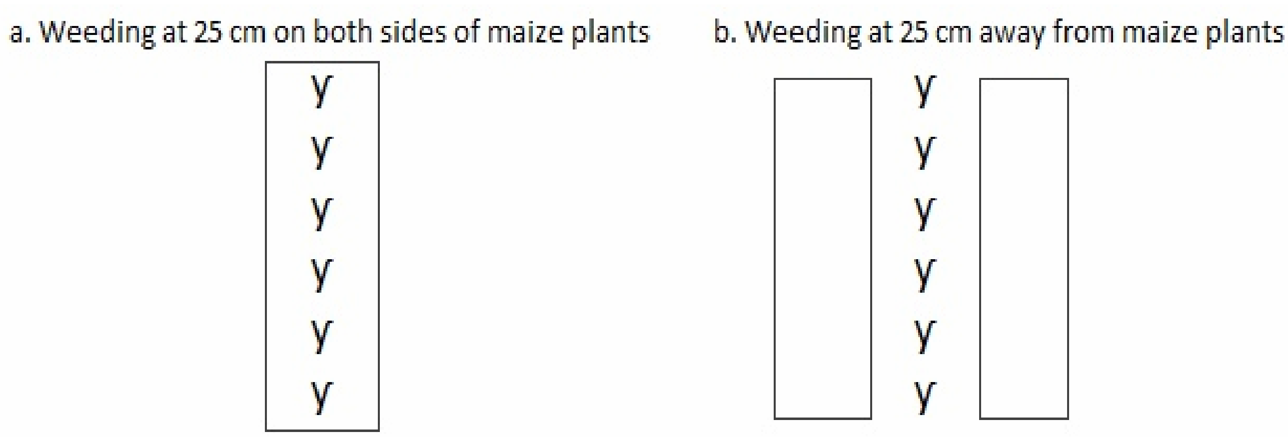

Fig. 1. Layout of weeding maize plant (a) 25 cm on both sides (b) no weeding at 25 cm.

Results and Discussion

Dry weed biomass (kg ha^{-1}): Weeds pressure and combinations of macro-nutrients had significant ($p \leq 0.05$) effect on dry weed biomass (Table 1). Means of the weed pressure showed that higher dry weed biomass (155.6 kg ha^{-1}) was observed in weedy check that was statistically at par with weeding 25 cm away from the crop rows (153.2 kg ha^{-1}). Application of atrazine plus S-metolachlor showed promising results by suppressing weeds and thus resulted in less dry weed biomass (53.6 kg ha^{-1}). Weeding at 25 cm close to crop rows gave 140.4 kg ha^{-1} dry weed biomass, which was less than the weeding 25 away from the maize plants. These results indicated that the maize plants suppressed the growth of weeds, present in the immediate vicinity and thus less biomass was recorded as compared to weedy check and weeding 25 cm away from maize. While means of the fertilizers showed that less weed biomass (94.3 kg ha^{-1}) was noted in control and highest dry weed biomass (140 kg ha^{-1}) was recorded in potassium (K) treated plots. This value was followed by 136 kg ha^{-1} recorded in farmyard manure (FYM). Other treatments like N, P, NP, PK, NK, NPK and control produced 125.8, 127.5, 123.4, 133.6, 130.7, 120.5 and 136.0 kg ha^{-1}, respectively. Less weed biomass in control was probably due to nutrients deficiency. Thus it can be concluded that application of nutrients benefit the crop and weeds as well. By comparing the mean values, all the fertilizers as sole or in combination, significantly affected the dry weed biomass as compared to control. The application of herbicide and fertilizers significantly and differently affected the dry weed biomass. Thus, herbicides application is correlated negatively with dry weed biomass (Subhan *et al*., 2007) and potassium application is correlated positively (Sileshi & Mafongoya, 2003). In light of the present studies it could be concluded that in the potassium treated plots, the crop plants were comparatively weaker due to absence of N and P and thus the available nutrients were shared by weeds and maize plants. While in control (no fertilizer) plots, nutrients deficiency resulted in less weed biomass. It has already been reported that weed consume greater amount of nutrients as compared to the associated crop (Galal & Shehata, 2015). Thus the associated weeds are harmful for the crop plants in term of nutrients and moisture absorption. These might be the reasons that weed significantly decrease the grain and biological yield of maize. As majority of the farmers use the weeds for fodder purpose in developing countries, therefore they prefer the weeds present in maize, to get bigger vegetative growth and then harvest for fodder purpose. While on the other hand, this perception decrease the grain yield of maize. Thus proper training of the farmers is needed to manage the weeds well in time to avoid the yield losses. The major weed species present in the experiment field were; *Echinochloa crus-galli* L. (Barnyard grass), *Digiteria sanguinalis* L. (Large crabgrass), *Cyperus rotundus* L. (purple nutsedge), *Convolvulus arvensis* L. (Field bindweed), *Trianthema portulacestrum* L. (Horse purslane), *Cynodon dactylon* L. (Bermuda grass), *Portulaca olereacea* L. (Common purslane), *Euphorbia prostrata* L. (Prostrate sandmat), *Digera arvensis* L. (False ammaranth), *Sorghum halepense* L. (Johnson grass), and *Xanthium strumarium* L.(Common cocklebur). The effective weed control due to herbicide and the weed suppression by maize plants in the vicinity of 25 cm are interesting results that could be used in integrated weed management approaches.

Plant height (cm) of maize: Means of the weed pressure (Table 2) showed that statistically tallest plants (196.2 cm) were recorded in herbicide treated plots. While shortest plants (153.7 cm) were recorded in weedy check. The plant height in weeding at 25 cm close to rows and 25 cm away from maize plants were statistically comparable by producing plant height of 191.3 and 189.6 cm, respectively. While herbicide application resulted in effective weed control that resultantly favoured the growth of maize plants and thus taller plants were observed. As increase in dry weed biomass cause reduced plant height of maize (Fuksa *et al*., 2004), therefore weed management in maize is an important component of production technology of maize. It is believed that taller plants can suppress the weeds growth however, the weeds growth at initial stage of maize can significantly affect the growth of maize. Like weed pressure, fertilizer application significantly ($P \leq 0.05$) affected the plant height of maize. Taller plants (200.1 cm) were observed in NPK treated plots, followed by NP (196.3 cm), P (189.1 cm) and NK (186.6 cm), while shorter plant height of 154.2 cm was observed in control followed by K treated plots (167.9 cm). The present findings showed that application of N as sole or in combination with other fertilizers, increased the plant height as compared to the rest of the treatments. As nitrogen acts as building blocks in the plant growth and development therefore taller plants were recorded in N treated plots (Rehman *et al*., 2010). Application of N in combination with PK, significantly increase the plant height of maize (Law-ogbomo & Law-ogbomo 2009) that will ultimately suppress weeds. However, weed competition at initial growth stage of maize crop should be addressed. Pakistani soil is not considerably deficient in K therefore, application of K did not show any significant effect on the plant height of maize. In light of these findings, it is suggested that in addition to weed control, N must be applied to get higher yield of maize. In developing countries like Pakistan, stover yield (plant biomass) of maize are equally important because the dry plants of maize are used as feed for livestock, especially when there is no fodder crop in winter. Therefore, this increase in plant height might be of interest as higher biomass is a desirable trait of maize for the farmers. In cool regions of the country, the maize is grown for grain as well as for fodder because there is scarcity of fodder during the snow. The only option in these hilly and temperate areas is the silage or storage of cereals like maize and wheat straw. Therefore taller plants will provide more biomass to be used as fodder and, this approach might be of interest in all the developing countries where maize is grown.

Table 1. Dry weed biomass (kg ha^{-1}) under different weeds pressure and fertilizer's combinations.

Fertilizer	Weeding at 25 cm	Weed pressure			Means
		No weeding at 25 cm	Primextra gold	Weedy check	
N	140.0	153.2	54.5	155.5	125.8 f
P	143.0	155.3	54.9	156.5	127.5 e
K	161.3	166.7	62.3	169.7	140.0 a
NP	133.0	151.7	54.9	154.0	123.4 g
PK	154.7	160.1	57.7	161.7	133.6 c
NK	148.7	157.7	56.4	159.9	130.7 d
NPK	126.7	148.7	54.0	152.7	120.5 h
FYM	156.3	162.9	60.7	164.1	136.0 b
Control	100.3	122.7	27.3	126.7	94.3 i
Means	140.4 b	153.2 a	53.6 c	155.6 a	

LSD 0.05 for means of weed pressure = 2.61
LSD 0.05 for treatments (fertilizer) = 1.54

Table 2. Plant height (cm) of maize under different weeds pressure and fertilizer's combinations.

Fertilizer	Weeding at 25 cm	Weed pressure			Means
		No weeding at 25 cm	Primextra gold	Weedy check	
N	206.0	203.7	210.0	157.7	194.3 b
P	199.7	194.3	205.0	157.3	189.1 c
K	174.0	174.7	174.7	148.3	167.9 f
NP	207.0	205.3	212.0	161.0	196.3 b
PK	185.7	186.7	195.0	153.3	180.2 d
NK	196.7	192.7	200.7	156.3	186.6 c
NPK	211.3	209.0	215.3	164.7	200.1 a
FYM	181.3	183.3	188.7	150.0	175.8 e
Control	160.3	157.0	164.7	134.7	154.2 g
Means	191.3 b	189.6 b	196.2 a	153.7 c	

LSD 0.05 for means of weed pressure = 2.33
LSD 0.05 for fertilizer = 2.69

Kernels cob^{-1}: Significantly higher number of kernels cob^{-1} (369) was observed (Table 3) in the herbicide treated plots which was followed by weeding 25 cm close to the maize plants (361). Less number of kernels cob^{-1} (227.1) was noted in weedy check which was significantly lower than weeding 25 cm away from maize rows (351.9). Thus weeding 25 cm close to maize plants increased the number of kernels cob^{-1} as compared to weeding 25 cm away from maize plants. The present results confirmed the earlier results (Khan *et al*., 2013), that presence of weeds decrease the yield related traits of maize. Means of the fertilizers showed that 384.9 kernels cob^{-1} was observed in NPK treated plots followed by NP (372.2), N (352.3) and P (346.5). While significantly less number of kernels cob^{-1} (230.2) was noted in control which was closely followed by K (274) and FYM (313) as shown in Table 3. These results indicated that the higher number of kernels cob^{-1} in herbicide treated plots was probably due the availability of more nutrients to maize crop due to weed suppression. Overall, N in combination with P provided more kernels cob^{-1} as compared to P, K, PK, FYM. While reporting the results of similar studies, Amanullah *et al*. (2014) claimed that NPK fertilization enhanced grains cob^{-1} of maize. In light of these findings, it is suggested that weeds should be managed in maize crops to avoid crop losses. In addition to weed control, application of NP increased number of kernels. Weeds removal in the close vicinity (25 cm) of crop plants produced significantly higher number of kernels. However, comparing the results with herbicide treated plots, it was observed that kernels cob^{-1} in herbicide treated plots was higher as compared to the rest of weed control treatments. Thus it can be inferred from the present results, that presence of weeds within 25 cm are more harmful for the growth of maize plants as compared to the weeds present 25 cm away from the crop plants. However, interestingly, the weeds at 25 cm away from crop plants were also found harmful when compared to weed control by herbicides. Thus complete removal of weeds from maize field is suggested for getting higher yield. In a similar study Tahir *et al*. (2009) suggested that yield attributing traits of maize were increased with the application of pre-emergence herbicides and nitrogen application (Abid *et al*., 2015).

Table 3. Kernels per cob of maize under different weeds pressure and fertilizer's combinations.

Fertilizer	Weeding at 25 cm	Weed pressure			Means
		No weeding at 25 cm	Primextra gold	Weedy check	
N	391.7	381.7	405.0	231.0	352.3 c
P	386.3	375.7	397.3	226.7	346.5 cd
K	289.0	280.7	310.0	216.3	274.0 g
NP	418.7	410.7	425.7	233.7	372.2 b
PK	373.0	362.7	368.0	223.0	331.7 e
NK	380.7	369.3	381.0	231.0	340.5 d
NPK	429.3	423.3	432.3	254.7	384.9 a
FYM	343.3	329.0	353.7	227.0	313.3 f
Control	237.7	234.3	248.0	200.7	230.2 h
Means	361.1 b	351.9 c	369.0 a	227.1 d	

LSD 0.05 for weed pressure = 6.61
LSD 0.05 for fertilizer = 7.55

Table 4. Biological yield (kg ha^{-1}) of maize under different weeds pressure and fertilizer's combinations.

Fertilizer	Weeding at 25 cm	Weed pressure			Means
		No weeding at 25 cm	Primextra gold	Weedy check	
N	8540.0	8447.3	8671.3	7630.0	8322.2 c
P	8474.7	8332.7	8543.0	7497.3	8211.9 d
K	8129.3	7555.0	8214.0	7371.0	7817.3 h
NP	8634.7	8581.7	8788.3	7656.7	8415.3 b
PK	8269.3	7970.0	8362.3	7463.3	8016.3 f
NK	8384.3	8160.3	8422.0	7533.3	8125.0 e
NPK	8758.3	8696.3	8892.3	7865.7	8553.2 a
FYM	8195.7	7831.7	8273.3	7401.3	7925.5 g
Control	6717.0	6250.7	7060.0	6944.7	6743.1 i
Means	8233.7 b	7980.6 c	8358.5 a	7484.8 d	

LSD 0.05 for weed pressure = 9.67
LSD 0.05 for fertilizer = 21.09

Biological yield: Statistically, higher (8358.5 kg ha^{-1}) biological yield was recorded in herbicide treated plots (Table 4) followed by weeding 25 cm close to maize plants. While lower biological yield (7484.8 kg ha^{-1}) was recorded in weedy check plots followed by weeding 25 cm away from maize rows. The biological yield recorded in weeding at 25 cm close to maize plants (8233.7 kg ha^{-1}) and in weeding at 25 cm away from maize plants (7980.6 kg ha^{-1}) was statistically different. This showed that weeding close to maize rows benefited the crop more as compared to weeding 25 cm away from maize rows. Due to severe infestation of weeds, higher biological yield of maize was observed in herbicide treated plots (Munsif *et al*., 2009) therefore, herbicide application is considered important factor that increase the biological yield.

Mean values of the treatments indicated that higher biological yield (8553.17 kg ha^{-1}) was observed in NPK treated plots, followed by NP and N, which produced the biological yield of 8553.2, 8415.3 and 8322.2 kg ha^{-1}, respectively. The combination of N with any other macro-nutrients increased biological yield except NK combination that produced 8125 kg ha^{-1}. Lower biological yield in control (6743.1) was followed by FYM (7925.5 kg ha^{-1}). Amanullah *et al*. (2014) also observed that NPK application increased the biological yield because NP acts as building blocks in the plant growth and development. Data showed that presence of weeds significantly decreased the biological yield of maize and application of N and P positively affected biological yield. In Pakistan the grain yield and plant biomass are equally important for farmers because dry and fresh maize plants are used for fodder purpose. Thus any increase in biological yield will favor the farmers' interest. It was observed during the present studies, that weeds removal close to crop rows increased the biological yield probably due to availability of more nutrients and moisture for the crop plants. Pakistani soil is deficient in N and P (Anon., 2006), therefore, application of these nutrients directly affects the growth and development of crop plants. These findings suggest that weeds should be controlled and balanced dose of fertilizers should be applied to maize crop for getting higher yield of maize. The combination of NPK (Amanullah, 2015) has positive effects on the overall growth of cereals as compared to sole or improper ratio of NPK. Therefore, the balanced population and nutritional status of the soil decide the yield of the crop (Li *et al*., 2015).

Table 5. Grain yield kg ha^{-1} of maize under different weeds pressure and fertilizer's combinations.

Fertilizer	Weeding at 25 cm	Weed pressure			Means
		No weeding at 25 cm	Primextra gold	Weedy check	
N	4076.7	3943.0	4262.3	3131.0	3853.3 c
P	4003.3	3875.3	4251.0	2919.0	3762.2 d
K	3380.0	3344.0	3838.7	2451.7	3253.6 h
NP	4191.3	4080.3	4487.0	3195.0	3988.4b
PK	3667.0	3446.3	3965.3	2732.3	3452.8 f
NK	3824.3	3667.0	4133.3	2879.0	3625.9 e
NPK	4327.7	4313.3	4598.3	3627.7	4216.8 a
FYM	3573.3	3417.0	3916.0	2545.7	3363.0 g
Control	1955.7	1964.3	2155.7	2049.7	2031.3 i
Means	3666.6 b	3561.2 c	3956.4 a	2836.8 d	

LSD 0.05 for weed pressure = 46.78
LSD 0.05 for fertilizer = 68.66

Grain yield kg ha^{-1}: Grain yield is the final yield that determines the profitability of enterprise. Data (Table 5) showed that weed pressure and various fertilizers significantly affected grain yield of maize. Means of the weed pressure showed that higher (3956.4 kg ha^{-1}) grain yield was recorded in plots treated with atrazine plus S-metolachlor followed by weeding at 25 cm close to maize plants (3666.6 kg ha^{-1}). While statistically minimum grain yield (2836.8 kg ha^{-1}) was noted in weedy check, followed by weeding at 25 cm away from maize plants (3561.2 kg ha^{-1}). Like other yield related traits of maize, weeding close to maize rows was beneficial for the maize plants in terms of grain yield. Thus decreasing weed pressure, increased the grain yield of maize (Baghestani *et al*., 2007). Higher grain yield in herbicide treated plots was probably due the availability of more nutrients to maize crop. Data further revealed that NPK application produced maximum grain yield (4216.8 kg ha^{-1}) followed by NP (3988.4 kg ha^{-1}). Whereas minimum grain yield (2031.3 kg ha^{-1}) was recorded in control (no fertilizer), followed by FYM (3363 kg ha^{-1}). This might be due to less nutrient availability to the crop plants. N and P are major nutrients and need in higher amount for maize plants, therefore the maize plants were not properly nourished under different weeds pressure that consequently negatively affected the growth and development. Because, inorganic fertilizers improved the grain and straw yields (Quimbo & Mamaril, 2015). In light of our findings, it could be concluded that P content is a crucial factor in germination and seedlings metabolism (White & Veneklaas, 2012). Probably, the poor decomposed FYM may not show good results due to unavailability of nutrients to the crop plants at early stage. The present results indicated that weeds can significantly affect the grain yield of maize. Therefore, it is suggested that weeds should be managed in maize crops to avoid grain yield losses. In addition to weed control, fertilizer, like nitrogen and phosphorus must be applied to get higher yield of maize. Herbicide application and nutrients like N and P can increase the grain yield of maize and growth Khan *et al*. (2013).

Net income: The use of N, P, K, FYM, handing weeding and herbicides increased the cost of production but resultantly increased the net income (Fig. 2). Weedy check and control (no fertilizer application) proved the most expensive by giving minimum net return, while application of herbicides resulted in maximum net income. Similarly the net income from fertilizer treatments was different, depending on the combination of fertilizers. However, N alone and in combination with P, proved economical by giving higher net income. Hand weeding either 25 cm close to maize rows or 25 cm away from maize rows proved expensive and thus gave less income. The concept of hand weeding is decreasing in the country as herbicide application is proving cheaper and easy. However, the farmers having small area under maize and where weeds are used as fodder, the net income may be different. In northern areas like Hindukush, Hamalayas and Karakuram, maize is grown in small terraces, thus manual weeds removal at proper time might be more profitable for the farmers instead of using herbicide. Therefore, the net income may vary from region to region due to the use of weeds for fodder and the availability of cheap labour. FYM is available in small quantities, and the use of NP is not common in hilly areas, therefore the net income may vary in such regions. While in other parts of the country, the farmers have large land holdings and summer maize is popular. Therefore, the use of herbicides and fertilizers might be more profitable. Herbicidal control of weeds is considered as an attractive approach by farmers, due to higher efficiency (Ali *et al*., 2015) as uncontrolled weeds significantly decrease the crop yield and cause lower income (Muhammad *et al*., 2011). N and P fertilizers in combination with herbicides application is recommended for getting high income. We calculated the prices for grain yield only. But the dried plants are fed to animals and used as fuel in many developing counties. Therefore the net income might be different from region to region and country to country, due to the different uses of dried maize plants. It is easy to remove weeds that are away from the maize plants as compared to the weeds that are present close to the maize plants. Therefore the labour will be proved more expensive in such cases. Maize is shallow rooted crop, therefore weeding close to maize rows may result in damage to roots of the crop plants. Therefore weed 25 cm away from maize plants take less time and hence less labour is required. This ultimately increases the cost of production which results in decreased net income. This approach is specific for developing countries with resource deprived farmers. The judicious use of NP and weeding close to crop rows might be of more interest in developing countries. Thus the net income obtained in this study might be of more interest to the farmers in the developing countries.

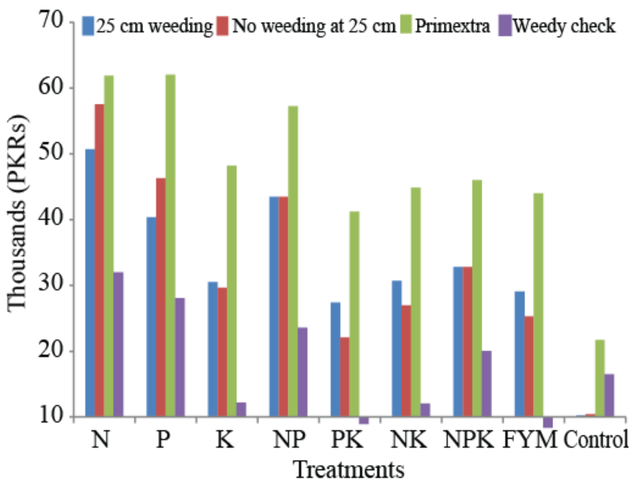

Fig. 2. Net income under different weed pressures and fertilizer combinations.

Conclusion

All the weeds recorded in the experimental fields proved competitive with maize. Therefore, weed management needs to be addressed in growing maize. As maize is grown in summer therefore weed control using hand weeding is practically impossible if the area is larger. But small farmers may be able to use hand weeding. Therefore application of Primextra gold is effective and economical for farmers having large area. While manual weeding at 25 cm close to maize rows or 25 cm away from maize rows affect the grain yield differently. Thus weeding close to crop rows benefit the crop more as compared to weeding at 25 cm away from maize plants. To get maximum grain yield and net return, the herbicide application in combination with nitrogen and phosphorus is the best and profitable for maize growers in developing countries.

References

Abid M., I. Khan, F. Mahmood, U. Ashraf, M. Imran and S.A. Anjum. 2015. Response of hybrid rice to various transplanting dates and nitrogen application rates. *The Philipp. Agric. Sci.,* 98(1): 98-104.

Achieng, J.O., G. Ouma, G. Odhiambo and F. Muyekho. 2010. Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, western Kenya. *Agric. Bio. J. North Amer.,* 1(4): 430-439.

Ali, H.H., A. Tanveer, M. Naeem, M. Jamil, M. Iqbal, M.M. Javaid and M.S. Kashif. 2015. Efficacy of pre-emergence herbicides in controlling *Rhynchosia capitata*, an emerging summer weed in Pakistan. *The Philip. Agric. Sci.,* 98(3): 301-311.

Amanullah, K.M. Kakar, A. Khan, I. Khan, Z. Shah and Z. Hussain. 2014. Growth and yield response of maize (*Zea mays* L.) to foliar NPK-fertilizers under moisture stress condition. *Soil Environ.,* 33: 116-123.

Amanullah. 2015. Specific leaf area and specific leaf weight in small grain crops wheat, rye, barley, and oats differ at various growth stages and NPK source. *J. Plant Nutrit.,* 38(11):1694-1708

Anonymous. 2006. http://prr.hec.gov.pk/Chapters/907s-3.pdf. (Date retrieved June 10, 2015).

Asghar , a. Ali, W.H. Syed, M. Asif, T. Khaliq and A.A. Abid. 2010. Growth and yield of maize (*Zea mays* L.) cultivars as affected by NPK application in different proportion. *Pak. J. Sci.,* 62(4): 211-216.

Baghestani, M.A., E. Zand S. Soufizadeh, A. Eskandaria, R.P. Azar, M. Veysi and N. Nassirzadeh. 2007. Efficacy evaluation of some dual purpose herbicides to control weeds in maize (*Zea mays* L.) *Crop Prot.,* 26: 936-942.

Das, P.C. 2005. Manures and Fertilizers. 2nd Ed. Kalyani Publishers, *New Dehli.pp*: 75-76.

Ding, L., K.J. Wang, G.M. Jiang, D.K. Biswas, H. Xu, L.F. Li and Y.H. Li. 2005. Effects of nitrogen deficiency on photosynthetic traits of maize hybrids released in different years. *Annals Bot.,* 96(5): 925-930.

Fuksa, P., J. Hakl, D. Kocourkova and M. Vesela. 2004. Influence of weed infestation on morphological parameters of maize (*Zea mays* L.). *Plant Soil Envir.,* 50(8): 371-378.

Galal, T. and H.S. Shehata. 2015. Impact of nutrients and heavy metals capture by weeds on the growth and production of rice (*Oryza sativa* L.) irrigated with different water sources. *Ecol. Indicat.,* 54: 108-115.

Hashim, S., K.B. Marwat, M. Saeed, M. Haroon, M. Waqas and Shahfahad. 2013. Developing a sustainable and ecofriendly weed management system using organic and inorganic mulching techniques. *Pak. J. Bot.,* 45(2): 483-486.

Khan, M.A., S. Kakar, K.B. Marwat and I.A. Khan. 2013. Differential response of (*Zea mays* L.) in relation to weed control and different macronutrient combinations. *Sains Malays.,* 42 (10): 1395-1401.

Law-ogbomo, K.E. and J.E. Law-ogbomo. 2009. The performance of *Zea mays* as influenced by NPK fertilizer application. *Not. Sci. Biol.,* 1:59-62.

Li, .J, R.Z. Xie, K.R. Wang, P. Hou, B. Ming, Y.Q. Guo, Y.L. Sun, G.Q. Zhang, R.L. Zhao and S.K. Li. 2015. Changes in plant-to-plant variability among maize individuals and their relationships with plant density and grain yield. *The Philipp. Agric. Sci.,* 98(1): 89-97.

Muhammad, N., A. Sattar, M. Ashiq and I.Ahmad. 2011. Efficacy of pre and post emergence herbicides to control weeds in chickpea (*Cicer arietinum* L.). *Pak. J. Weed. Sci. Res.,* 17(1): 17-24.

Munsif, F., K. Ali, I. Khan, H.U. Khan and M. Anwar. 2009. Efficacy of various herbicides against weeds and their impact on yield of maize. *Pak. J. Weed. Sci. Res.,* 15: 191-198.

Quimbo, M.C. and C.P. Mamaril. 2015. Organic fertilizer efficacy and financial viability in upland rice (*Oryza sativa L.*) production. *The Philipp. Agric. Sci.,* 98(2): 174-189.

Rashid, A. and K.S. Memon. 2001. Soil and fertilizer phosphorus. *In*: Soil Sci. *National Book Foundation, Islamabad, Pakistan.* (Eds.): B. Elena and R. Bantel. *pp.* 300-302.

Rashid, H., M.A. Khan, A. Amin, K. Nawab, N. Hussain and P.K. Bhowmik. 2008. Effect of *Parthenium hysterophorus* L., root extracts on seed germination and growth of maize and barley. *The Americas J. Plant Sci. Biotech.,* 2(2): 51-55.

Rashidi, S., A. Ebadi, G. Parmoon, S. Jahanbakhsh and Z. Haghighat. 2015. Effect of nitrogen source on bean growth under water deficit conditions. *The Philipp. Agric. Sci.,* 98(3): 279-285.

Rehman, A.U., A. Ali, M. Waseem, A. Tanveer, M. Tahir, M.A. Nadeem and S.I. Zamir. 2010. Impact of nitrogen application on growth and yield of Maize (*Zea mays* L.) grown alone and in combination with Cowpea (*Vigna unguiculata* L.). *Amer. Euras. J. Agri. Env. Sci.,* 7: 43-47.

Saeed, M., K.B. Marwat, G. Hassan, M. Azim Khan and I.A. Khan. 2010. Interference of horse purslane (*Trianthema portulacastrum* L.) with maize (*Zea mays* L.) at different densities. *Pak. J. Bot.*, 42(1):173-179.

Santos, G.A., G.H. Korndorfer and H.S. Pereira. 2015. Methods of adding micronutrients to a NPK formulation and maize development. ***J. Plant Nutrit.*** DOI: 10.1080/01904167.2015.1087569.

Seyyedi, S.M., M.K. Hosseini, P.R. Moghaddam and H. Shahandeh. 2015. Effects of phosphorus and seed priming on seed vigor, fatty acids composition and heterotrophic seedling growth of black seed (*Nigella sativa* L.) grown in a calcareous soil. ***Indust. Crops Prod.,*** 74: 939-949.

Sileshi, G. and P.L. Mafongoya. 2003. Effect of rotational fallows on abundance of soil insects and weeds in maize crops in Eastern Zambia. ***Appl. Soil Eco.,*** 23: 211-222.

Steel, R.G.D., J.H. Torrie and D.A. Pickey. 1997. Principles and Procedure of Statistics. A Biometric Approach 3rd Ed. McGraw Hill Book Co. Inc. New York, 480.

Subhan, F., N.U. Din, A. Azim and Z. Shah. 2007. Response of maize crop to various herbicides. ***Pak. J. Weed Sci. Res.,*** 13: 9-15.

Swanton, C.J., R. Nkoa and R.E. Blackshaw. 2015. Experimental methods for crop-weed competition studies. ***Weed Sci.,*** 63(sp1):2-11.

Swift, M.J., P.D. Seward, P.G.H. Frost, J.N. Qureshi and F.N. Muchena. 1994. Long term experiments in Africa: Developing a Database for sustainable land use under global change. In: Long term experiments in Agricultural and Ecological Sciences, R.A. Raleigh and A.E Johnston (Eds.). CAB International, Wallingford, UK, pp. 229-251.

Tahir, M., M.R. Javed, A. Tanveer, M.A. Nadeem, A. Wasaya, S.A.H. Bukhari and J.U. Rehman. 2009. Effect of different herbicides on weeds, growth and yield of spring planted maize (*Zea mays* L.). ***Pak. J. Life Soc. Sci.,*** 7(2): 168-174.

Waheedullah, M.A. Khan, S. Arifullah and M. Sadiq. 2008. Evaluation of Integrated weed management practices for maize (*Zea mays* L.). ***Pak. J. Weed Sci. Res.,*** 14(1-2): 19-32.

White, P.J. and E.J. Veneklaas. 2012. Nature and nurture: the importance of seed phosphorus content. *Plant Soil* 357: 1-8.

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