BIOCHAR AND INTEGRATED PHOSPHORUS MANAGEMENT SUPPRESS WEED DENSITY IN MAIZE CROP

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ABSTRACT

Weeds pose a significant threat to successful crop production. To meet the increasing future food demand, sustainable and efficient weed control remains a cornerstone practice. Usage of high doses of herbicides for killing weeds has created several ecological and environmental problems which cannot be overlooked. Therefore, other weed control practices and techniques should be adopted to minimize weed-crop competition and increase the growth and productivity of crop, instead of chemicals. An experiment was established at Agronomy Research Farm, the University of Agriculture Peshawar to evaluate the effects of biochar and organic-inorganic P sources on density, fresh and dry weight of weeds in maize during 2016. Experiment was executed using randomized complete block design and treatments included biochar (0 and 10 tonnes ha^{-1}) and three sources of P; FYM, PM and one DAP. Phosphorus at the rate of 100 kg ha^{-1} was applied in such a way that each plot received 50, 75 and 100% P from PM or FYM and the rest from DAP. Biochar and P sources significantly affected density, fresh and dry weight of weeds at 25 and 50 days after sowing of crop. 10 tonnes ha^{-1} biochar reduced weed density and fresh and dry weight of weeds at both intervals i.e. 25 and 50 days after sowing. Similarly, lower weed density, weed fresh and dry weight with addition of PM or FYM and DAP in 50:50 ratios. Sole FYM and PM resulted in higher weed density and weeds fresh and dry biomass. It is concluded that 10 tons ha^{-1} biochar and P application 50% from FYM or PM and 50% from DAP improved maize growth and reduced weed competition.

Keywords: Biochar, organic-inorganic P sources, maize, weeds.

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INTRODUCTION

Maize (*Zea mays* L.) is the utmost yielding crop among cereals (Zhao *et al*., 2020), grown around the world to feed the alarmingly increasing world population, especially in developing countries like Pakistan where the available food and feed has already been outpaced by the increasing demand and lower supply. Among cereal crops, maize is 2nd important cereal crop of the world and 3rd (after wheat and rice) largest grown crop of Pakistan (Ali *et al*., 2020). In farming system of Khyber Pakhtunkhwa it is placed on 2nd position (after wheat). About 70% out of total maize production is consumed as staple food by farming communities, while the left over is used by starch or poultry industries or sold as food grains (Ali *et al*., 2012). According to economic survey of Pakistan, maize total production was 4.95 million tonnes by covering an area of 1.15 million hectares and average yield was 4313 kg ha^{-1}. Likewise, in KP maize grown area was 0.5 million hectares, total production was 0.92 tonnes while the average yield was 1984 kg ha^{-1} (MNFSR, 2016). Pakistan's climatic and soil conditions strongly favor the maize production but still compared to other developing countries, its yield and production is very low (Ali *et al*., 2016). Improper use of fertilizers, high weed competition, poor soil fertility status, availability of insufficient irrigation water at critical stages of crop growth, non-availability of high yielding verities and hybrids and lack of modern technologies and agricultural practices are the main reasons for low yield in Pakistan (Verma *et al*., 2011). Among various crop production dynamics, chemicals based farming system and improper fertilizers use and weed infestations cause significant losses in maize yield and yet need to be considered for improved production.

Weeds are the natural components of arable land communities which cause significant damage to crop yield and productivity by competing with crops during its active growth periods (Blackshaw *et al*., 2002). Although maize is tall and vigorously growing crop but still it is very sensitive to compete weeds at early growth stages (Farkas, 2006). Yield reduction due to weeds could vary due to varying weed species, biomass, density and level of infestation. Thus, understanding the nature and relationship between weed, crop and environment is of great importance to develop technology for effective crop management and to avert yield losses caused by weeds. Evans *et al*. (2003) listed 25 to 30 different annual and perennial weed species that putting higher maize yield and production at greater risk. Rehman (1985) reported 30% while Thobatsi (2009) reported 40-60% world-wide maize yield losses due to severe weed competition. In Pakistan, Rashid and Shahida (1987) has reported 45% yield losses due to weeds. However, Arif et al. (2012) and Madrid and Vega, (1976) have reported up to 80% yield losses due to uncontrolled weed populations.

Biochar (BC) is the product of organic materials that is produced by thermo chemical conversion of organic materials in oxygen limited condition (Lehmann *et al*., 2007). Biochar is receiving significant consideration due to its vital role in sequestering carbon and enhancing soil physio-chemical and biological properties, nutrients uptake and nutrient use efficiency (Zhao *et al*., 2020). The careful and balanced use of fertilizers is of great importance for sustainable crop production (Saffari *et al*., 2020). Phosphorus is must for better quality seed formation and is an essential plant nutrient required in large quantity (Gangnon *et al*., 2020). Phosphorus improves inflorescence, grain formation and ripening of plant by regulating the reproductive growth of crop (tang *et al*., 2020). The deteriorated soil health and fertility status, shortage of energy and higher costs of chemical fertilizers is urging the farmers to practice the organic fertilizers which are rich sources of crop nutrients and environmental friendly as well (Naeem *et al*., 2009). The soil health and fertility is greatly influenced by soil organic matter and its reduction not only affects soil fertility but also crop yield and economic return to farmers (Zhang *et al*., 2007). Organic and inorganic fertilizers applied in combination increase crop production without degrading soil and environment and may result in higher and sustainable productivity (Paul and Mannan, 2006). Rautaray *et al*. (2003) proposed that co-application of organic and synthetic fertilizers can increase nutrients availability especially NPK, soil organic carbon and growth and yield of crop.

The present experiment was, however, established to assess the response of weed density, weeds fresh and dry weight in maize crop to biochar and various ratios of organic-inorganic P sources.

MATERIALS AND METHODS

A field experiment was carried out to study the effects of biochar and organic-inorganic P sources on density, fresh and dry weight of weeds using randomized complete block design at Agronomic Research Farm, The University of Agriculture Peshawar during summer, 2016. The study location displays subtropical climatic conditions with an average annual rainfall of 350 mm. The experimental site has silty clay loam soil with alkaline pH (7.8). Treatments consisted of biochar (0 and 10 tons ha^{-1}) and various P sources (diammonium phosphate, poultry manure and farmyard manure). P was applied from organic-inorganic sources in such a way that 100, 75 and 50% P was obtained from organic (PM/FYM) and the rest from inorganic (DAP) source. A plot size of 4m x 4.5m was used, having 6 rows, each 4m long and 0.75m apart. Field was ploughed at proper moisture level and open pollinated 'Azam' variety at 30 kg ha^{-1} seed rate was sown. Strong bunds were made around each plot to avoid the mixing of biochar and organic sources from one plot to the other. Irrigation water was supplied considering critical crop growth stages and weather conditions.

Data recording procedure

Data were recorded on density, fresh and weight of weeds at two intervals i.e. after 25 and 50 days of sowing. Weed density was recorded by placing a quadrate of size 0.5m x 0.5m randomly at three different sites in each plot, counted and then averaged and converted into weeds density m^{-2}. Weeds were weighed with the help of a sensitive electronic balance and fresh weight was noted. Further, weeds were sun dried and weighed for recording the weeds dry weight.

Statistical analysis

In order to analyze data statistically, analysis of variance (ANOVA) technique suitable for the randomized complete block design was used. Least significant differences (LSD) test was used to separate means of data at 0.05 level (5%) of probability, when F values were significant (Jan *et al.*, 2009).

RESULTS AND DISCUSSION

Weed density (25 days after sowing)

Biochar and sources of P applied in various ratios indicated significant differences in weeds density 25 days after sowing of maize (Table-1), while their interaction effect was insignificant. The differences of control vs rest revealed lower weeds density (85) in control plots as compared with fertilized plots (125). Biochar application reduced weeds density. Plots treated with 10 tons ha^{-1} biochar showed lower weeds density (98) as compared with no biochar plots (113). Similar results have been described by Arif *et al*. (2012), who concluded from their study that biochar application significantly reduced weeds density as compared with no biochar. Application of organic P sources (FYM) alone resulted in higher density of weeds (145), while lower weeds density (104) was recorded in plots where P was applied from PM and DAP in 50:50 ratio, followed by P applied 50% from FYM and 50% DAP. Our results are also in agreement with the results of Ali *et al*. (2011) who found higher weeds density m^{-2} with FYM application. Jama *et al*. (1997) also reported that weeds density was higher in plots treated with organic manures as compared to control treatment.

Weeds fresh and dry weight (g m^{-2}) (25 days after sowing)

Data on weeds fresh and dry weight are reported in Table-1. Analysis of variance showed that biochar and P sources significantly varied fresh and dry weeds weight after 25 days of crop sowing while their interaction was found non-significant. The planned mean comparison of the data indicated higher weeds fresh and dry weight (188 and 58 g m^{-2}) in fertilized plots as compared with control treatment (128 and 40 g m^{-2}). Biochar application reduced weeds fresh and dry weight of weeds. Lower weeds fresh and dry weight (148 and 45 g m^{-2}) was recorded in biochar (10 tons ha^{-1}) amended plots as compared with no biochar plots. Among different P sources, higher weeds fresh and dry weight was recorded with incorporation of sole organic P sources; FYM and PM whereas lower weeds fresh and dry weight was recorded in plots where integrated P from FYM or PM and DAP in 50:50 ratios was applied. Similar results were reported by Arif *et al*. (2015) who stated that the possible reason for increase in fresh and dry weight of weeds with organic manures i.e. FYM application might be due to the potential of FYM carrying weed seeds and thus increases the bulk of seeds and chances of weeds emergence and nutrients uptake in the field. Our results are also in line with Azeem *et al*. (2014) and Dai *et al*. (2016) who reported higher weeds fresh and dry weight in plots fertilized with organic manures.

Weeds density (50 days after sowing)

Data regarding weeds density 50 days after sowing of maize are shown in Table-2. The analysis of data exhibited significant differences in weeds density 50 days after sowing in response to biochar and P sources, while their interaction was found insignificant. The planned mean comparison of control vs. rest indicated that higher number of weed (206) were counted in fertilized plots as compared to control plots (167). Reduced weeds density was observed in biochar treated plots. Biochar treated plots resulted in lower weeds density (179) as compared with no biochar plots (193). The findings of Arif *et al*. (2012) are in accordance with our results who observed reduced weeds density under biochar amendment. Regarding P sources, application of P alone from FYM resulted in higher weeds density (225) whereas lower weeds density was noted in plots where 50% P from PM or FYM was integrated with 50% P from DAP with weeds density of 186 and 188, respectively. Similar results are reported by Ali *et al*. (2011) and Arif *et al*. (2012) who reported higher weeds density in organic manures especially in FYM incorporated plots. Marwat *et al*. (2007) and Hossein *et al*. (2014) also stated that plots fertilized with organic manures produced higher weeds density.

Weeds fresh and dry weight (g m^{-2}) (50 days after sowing)

The data in Table-2 exhibit the weeds fresh and dry weight (g m^{-2}) as influenced by biochar and P sources. Statistical analysis of data indicated biochar and P sources brought significant changes in fresh and dry weight of weeds 50 days after sowing of crop, while their interaction was insignificant. The mean comparison of control vs. fertilized showed higher weeds fresh and dry weight (312 and 106 g m^{-2}) in fertilized plots as compared to control treatment (257 and 89 g m^{-2}). Application of biochar significantly reduced weeds fresh and dry weight. Lower fresh and dry weeds weight (272 and 94 g m^{-2}) was recorded in 10 tons ha^{-1} biochar incorporated plots as compared to no biochar treatments. Regarding P sources, higher weeds fresh and dry weight (342 and 118 g m^{-2}) was recorded with incorporation of sole organic P source i.e. FYM which was statistically similar with sole PM application. Lower weeds fresh and dry weight was recorded in plots where combined P was supplied in 50:50 ratios from PM or FYM and DAP. Our results are similar with results found by Boguzas *et al*. (2010) who reported higher weeds fresh and dry weights in organic manures incorporated plots. Ali *et al*. (2011) and Nadeem *et al*. (2008) also found similar results and reported higher weeds fresh and dry weight in plots fertilized with organic sources of crop nutrients.

CONCLUSION AND RECOMMENDATION

Based on experimental results, it is concluded that application of PM or FYM and DAP in 50:50 ratios along with 10 tons ha^{-1} biochar resulted in lower weed density, fresh and dry weight of weeds in maize and hence is recommended for better crop growth and reduced weeds competition

Table 1. Weed density, fresh weight (g) and dry weight (g) 25 days after sowing of maize as affected by biochar and P sources

P sources ratios	25 days after sowing		
	Weeds density	**Fresh weight (g)**	**Dry weight (g)**
100% FYM	145 a	217 a	67 a
75% FYM	131 bc	198 b	61 ab
50% FYM	107 d	161 c	49 c
100% PM	135 ab	202 ab	62 a
75% PM	123 c	183 b	56 b
50% PM	104 d	158 c	50 c
100% DAP	133 b	194 b	62 a
$LSD_{0.05}$	10.6	16.5	6.1
Biochar vs No-Biochar	**	**	**
Biochar (10 t ha^{-1})	98 b	148 b	45 b
No-Biochar	113 a	168 a	53 a
Control vs rest	**	**	**
Control	85 b	128 b	40 b
Rest	125 a	188 a	58 a
Interaction			
Biochar x P sources	NS	NS	NS

Table 2. Weed density, fresh weight (g) and dry weight (g) 50 days after sowing of maize as affected by biochar and P sources

P sources ratios	50 days after sowing		
	Weeds density	**Fresh weight (g)**	**Dry weight (g)**
100% FYM	225 a	342 a	118 a
75% FYM	212 b	320 b	106 b
50% FYM	188 c	287 c	96 c
100% PM	219 a	335 ab	114 ab
75% PM	204 bc	314 bc	108 b
50% PM	186 c	285 c	99 bc
100% DAP	194 c	300 c	104 bc
LSD	10.2	17.3	9.2
Biochar vs No-Biochar	**	**	**
Biochar (10 t ha^{-1})	179 b	272 b	94 b
No-Biochar	193 a	296 a	101 a
Control vs rest	**	**	**
Control	167 b	257 b	89 b
Rest	206 a	312 a	106 a
Interaction			
Biochar x P sources	NS	NS	NS

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