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Influence of contrasting canopy architecture on the yield of maize hybrids

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ABSTRACT

The yield and productivity of maize is influenced by several factors of which the orientation of canopy in time and space is a crucial one. A field study was undertaken at Agronomic Research Area, Department of Agronomy, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan during autumn 2015 to compare the impact of contrasting canopy architecture on yield and yield components of maize hybrids. Two maize hybrids with contrasting canopy architecture *viz.*, Pioneer 30Y87 (semi-erect canopy) and Monsanto's DK6789 (droopy canopy architecture) were sown in 75 cm spaced ridges. The experiment was laid out in Randomized Complete Block Design (split-plot arrangement) with three replications. Data on yield attributes of maize were recorded following standard procedures. Differences among treatments' means were compared using Tukey's honest significant difference test (HSD) at 5% probability level. Results revealed that there were significant differences among hybrids regarding the number of grains per cob, the 1000-grain weight and ultimately the yield of the maize crop. Almost all of the parameters were significantly affected by Hybrid 30Y87 and it attained the grain yield. This was due to its better light attenuating properties and the shading effect of its canopy which helped in suppressing the weeds growing underneath.

INTRODUCTION

Being a leading world cereal both in terms of production and productivity, maize ranks the world's third most important cereal crop after wheat and rice. It is the staple food for millions in many countries across the globe (Oerke and Dehne, 2004). Pakistani farmers obtaining from maize crop food, feed, fodder and raw material for industrial products for food (25%), animal feed (12%), poultry feed (49%), starch (12%), brewery (1%) and seed (1%) (Dass *et al.*, 2008). Maize is full of nutrition's, it provides starch, protein, oil, fibre, sugar and ash with the value 72, 10, 4.8, 9.5, 3.0 and 1.7% respectively (Chaudhry, 1983). Pakistan GDP mostly depends on agriculture and consists of four seasons in a year summer, winter, spring and autumn which suited to many crops like maize. In the present cropping system of Pakistan,

maize has significant value and contributes to the economy of Pakistan. It is on the third rank in Pakistan after wheat and rice and mostly used for food, feed and provides the raw material for industrial products like starch manufacturing (MINFAL, 2013).

C4 unique photosynthetic mechanism of maize crop helps it to produce high biological yield and grain yield in a short time (Dass *et al.*, 2008). Maize is belonging to family Poaceae annual cross-pollinated crop and physical appearance of this plant is tall, deep-rooted & determined and survive in warm temperature. Maize plant stands with the help of erect stem which originates alternate leaves. It produces tassel on the upper part and female inflorescence on the lower part. The structure of stalk is composed of many nodes and internodes. Internodes are of many shapes such as some are cylindrical, and others

are straight and but grooved on the lower part.

The area under cultivation of maize in Pakistan is 1043.94 thousand hectares with the yield 2906.78 thousand tons and an average yield of maize is 2784 kg ha⁻¹ in Pakistan (ANON, 2007). In Pakistan, for fodder purpose, it grows on 0.09 million hectares, and forage production is 0.96 million tones and average production of forage is 22.38 t ha⁻¹ (Govt. of Pakistan, 2012). Due to its succulent and palatable taste, it is delicious food for livestock and milk animals, it is short duration crop after plantation it takes 8-10 weeks for maturity and harvesting (Karlen *et al.*, 2002). Maize contribution to the total grain production is 6.4% and stabilizing the economy of the country. Best efforts are made by the farmers for maize production but in spite of these efforts, the yield is reducing. The reason behind that reduction is the lack of modern technology and recourses (Karlen *et al.*, 2002).

In Pakistan lack of water, micronutrient deficiency, inappropriate management, improper application of fertilizer and weed attack are major factors reducing the production of crops.

The biotic factors which are disturbing maize crop are weeds infestation, disease-causing agents, insect pests, rodents and wild animals. On the other hand, abiotic factor includes drought, hailstorm, floods, nutrient deficiency, soil type, topographic features. In maize cropping system the main yield reducing agent between biotic factors is weed infestation (Oerke and Dehene, 2004). According to an overall worldview, maize production reduced up to 40% and reach to the vulnerable condition due to high weed infestation (Oerke and Dehene, 2004). In weed crop competition weed compete for light, nutrients, water and carbon dioxide and also disturb the harvest index and reduce production of maize.

The loss in maize cropping system is caused by animal pests is 18%, fungal and pathogens disturb 16% and virus 2% but weed infestation is much higher than other factors reduce the production potential 37%. Except for the production losses weeds also influence the farmers and their family life by wasting their time in weeding. Most of the labour serves them up to 50% time in weeding. By suppressing the weeds can be reduced weed crop competition which improves the crop vigour, tillers, head size, kernel weight and increase the grain yield (Ellis-jones *et al.*, 1993). There was 25 to 80% reduction in yield of maize or total crop failure noticed where the full attack of weed was found (Chikoye & Ekeleme, 2003).

Different methods are used to control weeds due to which increased production is 77 to 96%. Kostov (2006) proposed that the production potential of forage can be increased by suppressing the weeds. Khan *et al.* (1998) proposed that plantation on proper time and best weed control practices are effective in suppressing weeds and increase the yield. Pakistan lost Rs 10 billion annually due to weeds infestation and their poor management.

There are different methods to control weeds cultural practices, biological control, mechanical and chemical weed suppression. Cultural practices can show a positive response but, in these practices, require more labour and time for weeding so these methods are costly. Sorghum and sunflower secretion can be used to control weeds in maize crop. (Narwhal *et al.*, 1999).

Differ type of mulches like remaining of crops, polythene sheet can be used to control weeds (Chakraborty 2008). Timely sowing of any crop can save from the weeds attack and can be achieved higher production (Mishri and Kailash, 2005). In late sowing of rice, variations in seasonal conditions and competition between crop-weeds for natural resources lead to a reduction in production same as in maize crop production will decrease (Caton *et al.*, 1999).

These limitations showed that chemical and herbicidal control of weeds is effective which suppress the weeds in a short time and increase the yield of maize (Patel *et al.*, 2013). Proper use of herbicide is beneficial for weed control (Khan and Haq, 2004). Khan and Haq describe that the use of herbicide kills the weeds properly reduce their density and increase the yield. Weeds can be controlled 65-90% by using the herbicides and 100 - 150% yield can be increased of maize (Nadeem *et al.*, 2006). For the proper usage of herbicides, there is a need to devise the best critical period of weed competition for the optimum use of herbicides.

The present study, therefore, was devised to explore a critical period of weed competition in maize hybrids with contrasting canopy characteristics under the agro-ecological conditions of Multan.

MATERIALS AND METHODS

Description of the experiment: A field study was undertaken during autumn 2015 at the Agronomic Research Area, Department of Agronomy, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan. The soil of the experimental site was sandy clay loam in texture. The experiment was laid out

in a split-plot design with the two hybrids (30Y87 with semi-erect canopy and DK6789 with drooping canopy) in the main plots and increasing duration of weed competition (weedy until 20, 40 and 60 days after sowing). Season-long weedy and weed-free plots were also kept for comparison. A seedbed of fine tilth was prepared by cultivating the soil thrice with tractor-mounted cultivator followed by planking. The crop was sown in the mid of July with the help of a manual dibbler. A fertilizer dose of 200: 100: 100 N: P: K kg ha⁻¹ in the form of urea, diammonium phosphate and sulfate of potash fertilizer was applied. The whole phosphorus, potassium and one-third of nitrogen were applied at the time of sowing with last ploughing. Remaining nitrogen was applied in two equal splits viz., vegetative growth and at silking. To safeguard the crop against insect pests and diseases, standard plant protection measures were adopted. Weeds were removed by hand hoeing as per treatments.

Data collection: Weeds in the weedy plots, kept for different periods, were sampled from two quadrats of 50 cm × 50 cm at the time of weed removal as per treatment. Weed community comprised of broadleaved, grasses and sedges. The crop was harvested on November 15, 2015. Grain yield was taken from an area of 5.5 m². It was then converted in t ha⁻¹.

Statistical analyses: The difference among treatments' means was compared using Tukey's honest significant difference test (HSD) at 5% probability level.

RESULTS

Maize grain yield: Weed competition throughout the crop duration resulted in greater yield losses (%) in both cultivars. However, yield losses were more profound in case of a hybrid with dropping canopy as compared to the hybrid with semi-erect canopy architecture. This difference is attributed to better light attenuating and the weed-suppressing ability of the later hybrid (Table 1).

Table 1. Influence of Maize hybrids with different canopy architecture, weed competition periods and their interaction on grain yield (t ha⁻¹).

Competition Periods	Hybrids (H)		Mean
	30Y87 (Semi-Erect Canopy)	DK67899 (Drooping Canopy)	
Season-long Weedy	4.20 h	3.55 i	3.87 G
Competition till 20 DAS	8.85 a	7.85 bc	8.35 AB
Competition till 40 DAS	8.22 b	7.15 d	7.68 C
Competition till 60 DAS	6.35 ef	5.00 g	5.67 E
Mean (H)	6.90 A	5.88 B	

Among the dominant weed species were *Cyperus rotundus*, *Trianthema portulacastrum*, *Alternanthera philoxerides* and *Cynodon dactylon*. Grain yield and weed biomass were inversely related to each other. Though

there was not a profound reduction in yield, however, the hybrid 30Y87 performed better even under high weed pressure (Table 2).

Table 2. Influence of Maize hybrids with different canopy architecture, weed competition periods and their interaction on Total weed density (m²).

Competition periods	Hybrids (H)		Mean
	30Y87 (Semi-Erect Canopy)	DK67899 (Drooping Canopy)	
Season-long Weedy	152.23	265.00	208.66 B
Competition till 20 DAS	245.33	369.67	307.50 A
Competition till 40 DAS	282.00	419.33	350.66 A
Competition till 60 DAS	275.67	398.67	337.17 A
Mean (H)	238.80 A	363.16 B	

DISCUSSION

The two hybrids with contrasting canopy architecture had notable differences in weed suppressing ability with DK6789 performing poorer than 30Y87. Weed density/number of weed and the subsequent dry biomass production were recorded in plots sown under the hybrid DK6789. This difference may be attributed to the difference in the growth pattern of the hybrids, 30Y87 being able to attenuate lighter and acquire greater plant height as compared to the hybrid DK6789. Weed competitive ability is reported to be closely associated with the plant height and the canopy architecture (Caton *et al.*, 2003). Likewise, another study reported that the early plant vigour could also be an important parameter in selecting the hybrids against weed suppression (Zhao *et al.*, 2006). Higher weed density at initial growth stages of the crop coupled with the poor ability of the crop to suppress/compete with the weeds can lead to complete crop failure. Even under weed-free conditions, the hybrid 30Y87 recorded 11% more grain yield (9.07 t ha^{-1}) as compared to the hybrid DK6789 (8.20 t ha^{-1}). Season-long weed competition resulted in highest weed biomass causing maximum yield loss as compared to weed-free conditions. The critical period of weed-crop competition remained unaltered for both the cultivars, however it is suggested that early weeding in the hybrid DK6789 can make it produce to even higher yields. Weed biomass had a negative correlation with grain yield of both hybrids. Weed pressure in one of the key determinants of the length of the critical period. The relationship between grain yield and weed biomass established that the hybrid 30Y87 were capable of producing a higher yield than the hybrid DK6789 at short as well as prolonged weed infestation periods. /Though the yield of hybrid 30Y87 decreased with the increasing periods of weed infestation, nevertheless its performance/yield was still higher at all the stages as compared to the hybrid DK6789. This implies that higher weed biomass sustained after the critical period of weed control can lead to a marked decline in grain yield. A rapid crop canopy closure was achieved by the hybrid 30Y87, as it was planted in 75 cm spaced rows and its semi-erect leaves formed a net-like cover over the weeds. The same was true for the droopy canopy but the semi-erect canopy had an advantage over it; as it was able to harness more light.

The information from the above study suggests that though the critical period for weed control remained

unaltered for both the hybrids, yet the extent to which weeds were suppressed by their canopy architecture, had a profound difference. It is therefore suggested that coupling crop canopy architecture with the best management practices can curtail the losses caused by weeds and this particular aspect can be considered in formulating an integrated weed management strategy.

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