Research Article

Morpho-phenological traits of sugar beet genotypes as influenced by organic and inorganic fertilization

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Abstract

To investigate the effect of organic and inorganic fertilization on the morpho-phenological traits of sugar beet genotypes (*Beta vulgaris* L.) an experiment was conducted at New Developmental Farm, The University of Agriculture, Peshawar, during winter 2011-12. The design used was randomized complete block design with split plot arrangement. Three replications were used in this experiment. Treatments consists of organic and inorganic fertilizers treatments e.g., (control, Farm yard manure @ 10 t ha⁻¹, maxicrop sea gold (extract of sea weeds @ 5 lit ha⁻¹ was sprayed at the foliage), Higo organic plus (composted manure @ 5 t ha⁻¹), and three nitrogen and phosphorus levels, NP (90:60), NP (120:90), NP (150:120) kg ha⁻¹. Three sugar beet genotypes Sandrina, Serenada and Kawe Terma were also studied in this experiment. The result showed that highest number of leaves plant⁻¹ (27.7), leaf area (170.8 cm²), leaf area index (3.9) and beet length (35.8 cm) were recorded with the application of NP levels at the rate of 150:120 kg ha⁻¹. Highest beet weight plant⁻¹ (1 kg), beet diameter (11.4 cm) and unit area biomass (109.2 t ha⁻¹) with the application of Nitrogen and Phosphorus at the rate of 120:90 kg ha⁻¹. Sugar beet genotype Sandrina show highest leaves plant⁻¹ (21), beet length (32.7 cm) and unit area biomass (75.6 t ha⁻¹) followed by Serenada. Kawe Terma show maximum leaf area (138.3 cm²). It is clear from the results that the sugar beet genotype sandrina and Serenada show higher yield components as compared to sugar beet genotypes Kawe Terma. In case of fertilizers treatments the results of Nitrogen and Phosphorus level at the rate of 120:90 kg ha⁻¹ was better. Application

of Nitrogen and Phosphorus levels at the rate of 120:90 kg ha⁻¹ and sugar beet genotype Serenada and Sandrina is better as compared to other sugar beet genotype Kawe Terma.

Keywords: Sugar beet (*Beta vulgaris* L.); Organic and inorganic fertilizers; Sugar beet genotypes; Leaf area; Leaf area index; Unit area biomass; Beet weight.

Introduction

Sugar beet (*Beta vulgaris* L.) the second most important sugar crop after sugar cane. Sugar beet belongs to family Chenopodiaceae. Sugar cane and Sugar beet are grown for sugar production in many countries of the world. Sugar beet is a biennial crop which completes its growth in two seasons, during the first season it develops a root where the sucrose is stored, and in the second season it produces flowers and seeds. Sugar beet occupied an area of 5.83 million hectare; with a total world production is 238.8 million tones and average yield of 40.84 t ha⁻¹ [1]. The total production of sugar beet in Pakistan is 64.1 thousand tones with an area of 2.3 thousand hectare; average yield is 34.4 t ha⁻¹ [2]. In Pakistan Khyber Pakhtunkhwa is the main producer of sugar beet. In Khyber Pakhtunkhwa, the total production of sugar beet is 64.1 thousand tones, with a total area of 1.9 thousand hectare, having an average yield of 33.7 tones ha⁻¹ [2]. The average yield of sugar beet in Pakistan is low as compared to other countries. The main reason for this low yield is the low and imbalance use of fertilizers. Soil fertility and crop productivity significantly increased due to the application of nitrogen [3]. Nitrogen is the key nutrient for enhancing sugar beet yield and production. Application of Nitrogen can improve leaf area, leaf area index, chlorophyll content and photosynthetic rate [4]. The highest beet and sugar yield was obtained with the optimum application of Nitrogen, Phosphorus and Potassium [5]. Phosphorus is the second primary nutrient for beets production. Phosphorus helps in structural integrity of cell membrane and also play important role

in energy transfer within the plants. Application of 120 kg P₂O₅ and 100 kg N ha⁻¹ can result in higher beet and sugar yield [5]. Higher sugar yield was obtained with the application of NP levels at the rate of 100-100 kg ha⁻¹ [6]. High cost of commercial fertilizers is also the main cause of low yield in Pakistan. Farm yard manure is the most important organic fertilizer, because it contains all nutrients required for plant growth. Application of farm yard manure can improve soil structure and increased the sugar yield 10 % when applied at the rate of 20 tones ha⁻¹ compared to control plots [7]. In wheat sugar beet rotation application of farm yard manure increase the sugar yield 5.41 t ha⁻¹, improve the soil properties and also increase the organic carbon from 0.81 % to 0.94 % [8]. Higher sugar production of 7.9 tons ha⁻¹ was obtained with the integrated application of farm yard manure and nitrogen [9]. The aim of this study was to find out the effect of sole application of organic fertilizers and inorganic fertilizers on the morpho-phenological traits of sugar beet genotypes.

Materials and Methods

Experimental site, experimental design and agronomic practices

The experiment on “effect of organic and inorganic fertilization on the morpho-phenological traits of sugar beet genotypes (*Beta vulgaris* L.)” was conducted at New Developmental Farm, The University of Agriculture, Peshawar, during fall 2011-12. The experiment was carried out in a randomized complete block design with split plot arrangements with three replications. The size of treatment plot was 3 x 5 m. Each plot consisted of 5 rows with a row to row distance of 60 cm and plant to plant 20 cm.

The experiment consisted of three sugar beet genotypes (Sandrina, Serenada and Kawe Terma), three organic fertilizers i.e., Higo organic plus (composted manure, it contains N 2%, P 3%, K 3%, organic matter 40%, organic carbon 11%, Zn 145 mg kg⁻¹, Cu 56 mg kg⁻¹, Fe 380 mg kg⁻¹ and 228 mg kg⁻¹), Maxicrop sea gold (sea weeds extract, Sargassum, Laminara Polysaccharide and Ascophyllum Nodosum), Farm yard manure (FYM was analyzed, the analysis showed that the FYM contains, N 1%, P 0.47% and K 0.67%) and three NP levels from inorganic fertilizers Urea and DAP (90:60), (120:90) and (150:120) kg ha⁻¹. Fertilizers Treatments were assigned to the main plots while sugar beet genotypes to the sub plot.

All phosphorus was applied at the time of seed bed preparation while nitrogen in two splits. Farm yard manure @ 10 tones ha⁻¹ and higo organic plus @ 5 t ha⁻¹ was incorporated in the soil at the time of seed bed preparation. Maxicrop sea gold (5 lit ha⁻¹) was sprayed after the emergence of the crop. Thinning was done in order to maintain a uniform plant population of 83333 plants ha⁻¹. The seeds were sown on ridges. Four hoeing of the field was done to eliminate weeds. Data was recorded on leaf area, leaf area index, number of leaves plant⁻¹, beet diameter at harvest, unit area biomass, beet weight plant⁻¹. The soil was analyzed the analysis are shown in (Table 1).

Table 1. Physico-chemical properties of experimental site at AUP, Peshawar.

S. NO.	Property	Unit	Value
1	Clay	%	32.90
2	Silt	"	53.20
3	Sand	"	13.90
4	Textural class	-----	Silty, clay, loam
5	pH (1: 5)	-----	7.91
6	EC (1: 5)	d S m ⁻¹	0.12
7	Organic matter	%	0.87
8	Lime (CaCO ₃)	"	15.4
9	Total nitrogen	"	0.08
10	AB-DTPA extractable P	mg Kg ⁻¹	5.76

Statistics

Data recorded were analyzed statistically using the software MSTATC and LSD test was applied to obtain the significant differences among the treatments and treatments interaction at 0.5% level of probability [10].

Results and discussion

Leaf area (cm²)

Data regarding leaf area are reported in table 2. Analysis of data showed that fertilizer treatments had significantly influenced leaf area of sugar beet genotypes. The interaction between sugar beet genotypes and fertilizers treatments was also significant. Maximum

leaf area (170.8 cm²) was recorded in plots that received NP levels at the rate of 150:120 kg ha⁻¹ while minimum (60.9 cm²) leaf area was recorded in control plots. The availability of high fertility level favored the maximum leaf area development because of the abundant nutrients availability. These results are in line with [4] who stated that increasing nitrogen rates can increase leaf area and [12]. In case of sugar beet genotypes kawe terma produce maximum leaf area (138.3 cm²) followed by Serenada (125.4 cm²) and Sandrina (120.8 cm²). The differences in leaf area could be due to the

genetic variations of the sugar beet genotypes.

Leaf area index

Data concerning leaf area index are shown in table 3. Statistical analysis of the data showed that treatments significantly affected leaf area index. The interaction between treatments and genotypes was also found significant. Maximum (3.9) leaf area index was recorded from treatment NP (150:120) while lower (0.7) was recorded in control plots. It may be due to sufficient amount of NP that produce maximum leaf area and hence leaf area index. Similar results are reported by [13] who stated that increasing nitrogen level up to 150 kg ha⁻¹ can increase leaf area index. These results are further justified by [4] and [14]. These results are in contrast to [12] who reported that maximum leaf area index can be achieved with the application of 200 kg N ha⁻¹.

Beet length at harvest (cm)

Data related to Beet length at harvest (cm) was shown in Table 4. Beet length at harvest of sugar beet genotypes was significantly affected by organic fertilizers and inorganic fertilizers. Maximum beet length (35.8 cm) at harvest was recorded in treatment NP (150:120) while minimum (22.1 cm) in check plots. These results are in line with [13] who reported that maximum beet length was obtained when nitrogen was applied at the rate of 150 kg ha⁻¹ and in contrast to [15] who reported that nitrogen has no effect on beet length and [12] who stated that beet length decreased when nitrogen rate increased from 100 kg N ha⁻¹. In terms of genotypes Sandrina (32.7 cm) show maximum beet length while Kawe Terma (27.7 cm) shows minimum. It may be due to the genetic makeup of the genotypes

Table 2. Leaf area (cm²) of sugar beet genotypes as affected by organic and inorganic fertilizers.

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	67	60	55.7	60.9 g
FYM (10 t ha ⁻¹)	107.7	122.7	129	119.8 e
Maxicrop Sea Gold (5 Liters ha ⁻¹)	99.7	121	90	103.6 f
Higo organic Plus (5 t ha ⁻¹)	111.7	125.7	154	130.4 d
NP (90:60)	132	148.7	167.7	149.4 c
NP (120:90)	155.7	153	178	162.2 b
NP (150:120)	171.7	146.7	194	170.8 a
Mean	120.8 b	125.4 b	138.3 a	

LSD_(0.05) for treatment (T) = 3.982

LSD_(0.05) for Genotypes (G) = 5.74

LSD_(0.05) for T x G = 15.21

Table 3. Leaf area index of sugar beet genotypes as affected by organic fertilizers and inorganic fertilizers.

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	0.8	0.8	0.5	0.7 g
FYM (10 t ha ⁻¹)	1.5	1.5	1.4	1.5 e
Maxicrop Sea Gold (5 Liters ha ⁻¹)	1.3	1.2	0.7	1.1 f
Higo organic Plus (5 t ha ⁻¹)	1.6	2.4	2.4	2.1 d
NP (90:60)	2.6	3.1	3.0	2.9 c
NP (120:90)	3.8	3.2	3.4	3.4 b

NP (150:120)	4.3	3.4	4.0	3.9 a
Mean	2.3	2.3	2.2	

LSD_(0.05) for treatment (T) = 0.169LSD_(0.05) for T x G = 0.462**Table 4. Beet length at harvest (cm) of sugar beet genotypes as affected by organic fertilizers and inorganic fertilizers.**

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	22.5	22.8	21	22.1 e
FYM (10 t ha ⁻¹)	31.1	32.7	27.3	30.4 c
Maxicrop Sea Gold (5 Liters ha ⁻¹)	29.6	25.6	22.4	25.9 d
Higo organic Plus (5 t ha ⁻¹)	33.1	30.4	25.8	29.8 c
NP (90:60)	35.6	34.1	30.6	33.4 b
NP (120:90)	37.2	33.8	33.6	34.9 a
NP (150:120)	40.1	33.1	34.1	35.8 a
Mean	32.7 a	30.4 b	27.7 c	

LSD_(0.05) for treatment (T) = 1.304LSD_(0.05) for Genotypes (G) = 1.240LSD_(0.05) for T x G = 3.280

Means followed by different letters are statistically different from each other at $P \leq 0.05$ using LSD test.

Maximum beet diameter (cm)

Data concerning to maximum beet diameter (cm) at harvest was shown in Table 5. Analysis of the data showed that treatments and genotypes significantly affected maximum beet diameter. Maximum beet diameter (11.4 cm) was recorded in treatment NP (120:90) followed by (10.5 cm) in treatment NP (150:120) while minimum (4.8 cm) in control plots. The reason might be that high fertility levels induce the maximum beet diameter by expanding the root accordingly, while control plots did not favour proper vegetative growth and hence roots of smaller diameter was obtained. These results are also confirmed by [15] who stated that nitrogen application increase the beet diameter and in contrast to [12] who stated that maximum beet diameter was obtained with the application of 200 kg N ha⁻¹. In terms of genotypes Sandrina (8.6 cm) and Serenada (8.6 cm) showed same beet diameter while in case of Kawe Terma beet

diameter was (7.5cm). It may be due to the genetic variations of the sugar beet genotypes.

Number of leaves plant⁻¹

Data concerning to Number of leaves plant⁻¹ was shown in Table 6. Analysis of data showed that treatments and genotypes had significantly affected leaves plant⁻¹. The interaction between treatments and genotypes was also found significant. Maximum leaves plant⁻¹ (25.7) were recorded in NP (150:120) followed by NP (120:90) while minimum (12.7) in maxicrop sea gold. Higher fertility level results in higher number of leaves plant⁻¹, as compared to lower NP levels, organic fertilizers and control. These results are confirmed by [7] who stated that higher number of leaves plant⁻¹ can be achieved, when NP was applied at high level. [16] also found that increasing nitrogen level from 130-160 kg ha⁻¹ can result in higher number of leaves plant⁻¹. In terms of genotypes

Sandrina and Serenada attained maximum (21) leaves plant⁻¹ while lesser (17.3) in Kawe Terma. It may be due to the genetic makeup of the genotypes.

Beet weight plant⁻¹ (kg)

Data regarding to beet weight plant⁻¹ are presented in Table 7. Analysis of the data showed that treatments significantly affected beet weight plant⁻¹ of sugar beet genotypes. The interaction between genotypes and treatments were also significant. Higher (1.0 kg) beet weight plant⁻¹ was recorded in treatment NP (120:90) followed by (0.9 kg) in treatment NP (150:120) while lower (0.2 kg) in control plots. The probable reason might be that plots that recieved NP (120-90) kg ha⁻¹ had a balance growth and root growth conducive to good crop development resulting in the top vegetative growth that further produce well developed roots with higher weight as compared to control. At higher fertility level most of the assimilates in the form of sucrose can be accumulated properly in the root tissue. These results are in line with [7] who stated that application of NP levels (100-100) kg ha⁻¹ can result in maximum beet weight. These results are in contrast to [13] who reported that maximum beet weight per plant can be achieved with the application of

150 kg N ha⁻¹. In terms of genotypes Sandrina and Serenada show maximum (0.7 kg) beet weight plant⁻¹ while Kawe Terma showed minimum (0.6 kg) beet weight plant⁻¹. It may be due to the genetic variations of sugar beet genotypes.

Unit area biomass (kg ha⁻¹)

The analysis of data showed that treatments and genotypes significantly affected Unit area biomass as shown in table 8. The interaction between treatments and genotypes was also found significant. Maximum (109.2 t ha⁻¹) Unit area biomass was recorded in plots treated with NP (120:90) followed by (105.4 t ha⁻¹) in NP (150:120) while lower (23.2 t ha⁻¹) in control plots. The reason might be that NP levels (120-90) favors higher vegetative growth which in turn produces beets of larger size and weight and increase the unit area biomass. These results are in contrast with [15] who stated that 80 kg N ha⁻¹ can sufficient to increase root and top fresh yield. In case of genotypes Sandrina gave maximum unit area biomass (75 .6 t ha⁻¹) while minimum (72.6 t ha⁻¹) was in case of Kawe Terma (Table 10). It may be due to the genetic makeup of the sugar beet genotypes.

Table 5. Maximum beet diameter (cm) at harvest of sugar beet genotypes as affected by organic fertilizers and inorganic fertilizers.

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	5	4.7	4.6	4.8 d
FYM (10 t ha ⁻¹)	8.8	8.5	5.3	7.5b c
Maxicrop Sea Gold (5 Liters ha ⁻¹)	6.6	7.4	5.9	6.6 c
Higo organic Plus (5 t ha ⁻¹)	8.4	9.4	7.8	8.5 b
NP (90:60)	9.4	8	7.4	8.3 bc
NP (120:90)	11.2	12.1	11	11.4 a
NP (150:120)	10.5	10.4	10.7	10.5 a
Mean	8.6 a	8.6 a	7.5 b	

LSD_(0.05) for treatment (T) = 1.77

LSD_(0.05) for Genotypes (G) = 0.50

LSD_(0.05) for T x G = 1.28

Table 6. Leaves plant⁻¹ of sugar beet genotypes as affected by organic fertilizers and inorganic fertilizers.

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	14	17	10	13.7 ef
FYM (10 t ha ⁻¹)	17	15	13	15.0 e
Maxicrop Sea Gold (500 Liters ha ⁻¹)	16	12	10	12.7 f
<i>Higo organic Plus</i> (5 t ha ⁻¹)	17	23	19	19.7 d
NP (90:60)	24	25	21	23.3 c
NP (120:90)	29	25	23	25.7 b
NP (150:120)	30	28	25	27.7 a
Mean	21 a	20.7 a	17.3 b	

LSD_(0.05) for treatment (T) = 1.720LSD_(0.05) for Genotypes (G) = 0.926LSD_(0.05) for T x G = 2.450**Table 7. Beet weight plant⁻¹ (kg beet⁻¹) at harvest of sugar beet genotypes as affected by organic fertilizers and inorganic fertilizers.**

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	0.2	0.3	0.2	0.2 f
FYM (10 t ha ⁻¹)	0.5	0.7	0.6	0.6 d
Maxicrop Sea Gold (5 Liters ha ⁻¹)	0.5	0.3	0.5	0.4 e
<i>Higo organic Plus</i> (5 t ha ⁻¹)	0.7	0.8	0.8	0.8 c
NP (90:60)	0.9	0.9	0.7	0.8 c
NP (120:90)	0.9	1.0	0.9	1.0 a
NP (150:120)	0.9	0.9	0.8	0.9 b
Mean	0.7 a	0.7 a	0.6 b	

LSD_(0.05) for treatment (T) = 0.04LSD_(0.05) for Genotypes (G) = 0.03LSD_(0.05) for T x G = 0.08**Table 8. Unit area biomass (t ha⁻¹) of sugar beet genotypes as affected by organic and inorganic fertilizers.**

Treatments	Genotypes			Mean
	Sandrina	Serenada	Kawe Terma	
Control	23.8	29.4	16.5	23.2 g
FYM (10 t ha ⁻¹)	58.8	69.2	59	62.3 e
Maxicrop Sea Gold (5 Liters ha ⁻¹)	51.6	38.3	47.2	45.9 f
<i>Higo organic Plus</i> (5 t ha ⁻¹)	76.6	77.7	92.6	82.3 d
NP (90:60)	90.8	94.8	88.5	91.4 c
NP (120:90)	106.2	112.1	109.4	109.2 a
NP (150:120)	121.2	99.8	95.3	105.4 b
Mean	75.6 a	74.5 ab	72.6 b	

LSD_(0.05) for treatment (T) = 1.37LSD_(0.05) for Genotypes (G) = 1.92

LSD_(0.05) for T x G = 5.08

Means followed by different letters are statistically different from each other at $P \leq 0.05$ using LSD test.

Conclusion

It is concluded from the present research that inorganic fertilizers significantly improve the morpho-phenological traits of sugar beet genotypes as compared to sole application of organic fertilizers. Application of NP at the rate of 120:90 kg ha⁻¹ produced maximum unit area biomass, beet weight plant⁻¹, and maximum beet diameter. Maximum leaf area, leaf area index, leaves plant⁻¹ was recorded with the application of NP at 150:120 kg ha⁻¹. Among sugar beet genotypes, Sandrina and Serenada performed better as compared to Kawe Terma. It was concluded from the present research that the sole application of organic fertilizers can not improve morpho-phenological traits of sugar beet genotypes; further research is needed on the combine application of organic and inorganic fertilizers.

Authors' contributions

Conceived and designed the experiments: B Ahmad. Performed the experiments: I Ahmad. Analyzed the data: I Ahmad. Contributed reagents/materials/analysis tools: M Ahmad, M kamran, HQ Fang, T Liu & M Ullah. Wrote the paper: I Ahmad & S Ali.

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