IMPACT OF NITROGEN, SULFUR LEVELS AND THEIR RATIOS ON WEED DENSITY, WEED BIOMASS, PLANT HEIGHT AND HARVEST INDEX OF MAIZE HYBRID 'BABAR'

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ABSTRACT

Nitrogen (N) and sulfur (S) affects weeds growth and yield of maize. Effect of N and S applied in various ratios on maize hybrid 'Babar' was assessed in a 2 year field experiment at Peshawar in 2011, 2013. Four N (120, 160, 200, 240 kg N ha^{-1}) and four S levels (20, 25, 30, 35 kg S ha^{-1}) were applied in three splits; a) at sowing, b) at V8 stage and c) at VT stage in ratios of 10:50:40, 20:50:30 and 30:50:20. Year (Y) significantly affected weed density (WD m^{-2}), weed biomass (WB g m^{-2}), plant height (PH cm) and Harvest index % (HI). Nitrogen (N) had significant effect on WB, PH and HI. Sulfur had significant impact on PH and HI only while Ratios (R) significantly affected WB and HI. High weeds infestation was recorded in 2013 compared to 2011. Each increment of N increased WD and PH up to 240 kg N ha^{-1} whereas HI index increased up to 200 kg ha^{-1}N further increase in N decreased HI and lowest HI was recorded with 240 kg N ha^{-1}. Higher level of S significantly increased PH and HI compared with lower S levels, while WD and WB were not significantly affected by S. In case of N and S ratios, more WB and PH and higher HI were observed at 30:50:20 where 30% of N and S were applied at sowing, 50% at V8 and 20% at VT stage. It is concluded that 200 kg N ha^{-1} and 35 kg S ha^{-1} applied in the ratio of 30% at sowing, 50% at V8 and 20% at VT stage performed better and is recommended for weeds control and obtaining higher HI of maize hybrid Babar.

Key words: Maize hybrid, nitrogen, sulfur, weed density, biomass.

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INTRODUCTION

Maize (*Zea mays* L.) is well adapted to the climate and soil of Pakistan. It is the world's most grown ranked third among cereal crops

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after wheat and rice (Ayisi and Poswall, 1997). Yet its yield in Pakistan is far below than other maize growing countries of the world (Amanullah *et al.*, 2009). Among other factors responsible for low yield of maize poor fertilizer application and weed management are the major causes of low yield (Fernandez *et al*. 2008). In most agricultural conditions, availability of usable nitrogen is the most limiting factor of high growth. The demand for N application further increase if hybrid maize is planted (Sawyer and Mallarino, 2007). The corn plant requires N soon after germination to initiate the growth of stem, leaves and ear structures. Inadequate N availability during the first 2 to 6 weeks after planting can result in reduced yield potentials. However, the majority of N is needed during the period of rapid growth at tasseling and silking stage. N availability during these growth stages is needed to ensure rapid growth and development of maize without supplying excess that potentially can be lost (Shanahan, 2011). Timing has a major effect on the efficiency of nitrogen management systems. Nitrogen application at the time when desperately needed by crop not only ensures availability of N in sufficient amount but also reduces potential losses of N due to leaching. Split application of N to maize is considered as useful management practice in order to provide N to the crop at time when needed and may not be lost through leaching (Shanahan, 2011). Split application of N reduce the chances of N leaching and allows the plant to maintain more green leaves for longer duration, which in turn increases photosynthesis, assimilate production and partitioning resulted in more grain yield (Randall and Schmitt, 2004).

Sulfur is considered a secondary nutrient; it is now becoming recognized as the 'fourth macronutrient', along with nitrogen, phosphorus and potassium. It is used in the formation of amino acids, proteins, and oils. It is necessary for chlorophyll formation, helps and activates certain enzymes and vitamins, and is a structural component of two of the 21 amino acids that form protein (Jamal *et al*., 2009). Sulfur deficiency symptoms show up as light green to yellowish color. Deficient plants are usually small and their growth is retarded (Jamal *et al.*, 2009).

Positive interactions of S with N have reportedly augmented yield over control levels in different cereals. This higher yield can be explained by hormonal effect of S through increased methionine in the vegetative tissues. This amino acid (methionine) is a recognized precursor in the biosynthesis of ethylene, one of the regulatory hormones of plant growth (Garcia *et al.,* 1999). In S deficient environments, it is expected that a higher N uptake will enhance nutrient use efficiency when S is added. At present N is applied in split doses, while S is applied as a basal dose. This may create imbalance in the supply of these nutrients during the growth and development of the crop because the metabolism of N and that of S are closely linked and play a central role in protein synthesis. The requirement of one element depends on the supply of the other, and the imbalance in their supply causes a reduction in the yield due to reduced uptake and its sulfur needs to be applied in split doses, along with N to ensure better growth and yield (Ahmad and Abidin, 1998).

Weeds are unwanted plants growing along with agricultural crops. Weeds compete with crops for space, sunlight, moisture and nutrients and thus reduce quantity and quality of production (Anderson *et al*., 1996). Weed infestation in cereals causes an enormous loss of worth Rs.10 billion per annum in Pakistan (Ahmad and Saeed, 1994). Maize being very sensitive to weeds competition may even result in crop failure (Anderson, 1996). The most serious weeds of maize are *Echinochloa cruss–galli, Leptochloa* sp*., Cyprus rotundus, Sorghum halepense, Cynodon dactylon, Digitaria sanguinalis, Convolvulus arvensis, Tribulus terrestris, Digera murricata and Portulaca oleracea* (Marwat, 1984). Weeds if not managed properly in time, the yield losses may reach to 35-70% (Ford and Pleasant, 1994; Teasdale, 1995). Limited research is available elaborating effect of split application of N and S at different growth stages in various ratios. Thus, the aim of this research was to study impact of different N and S levels applied in various ratios at three growth stages on weed density, weed biomass and yield of maize hybrid Babar.

MATERIALS AND METHODS

Experimental site, design and treatments

The experiment was conducted at University of Agriculture, Peshawar-Pakistan. It is located at 34° N and 71.3° E at 350 m above sea level. Summer daily maximum mean temperature ranges from 40 to 44 °C, while winter minimum temperature ranges from 4 to 5 °C. Annual rainfall ranges from 450 to 750 mm with more than 60% rainfall occur in summer (Amanullah *et al.,* 2009). Experimental plots were established in June 2011 at New Developmental Farm, The University of Agriculture Peshawar Pakistan. Maize hybrid Baber was planted on the established plots on 20th June 2011. Experiment was repeated on the same plots on 22nd June 2012 and on 25th June 2013 according to randomized complete block (RCB) design having three replications. Due to sever weeds infestation coupled with continuous rainfall, experiment in 2012 was failed. Four nitrogen levels (120, 160, 200 and 240 kg N ha^{-1}) and four sulfur levels (20, 25, 30 and 35 kg S ha^{-1}) were applied in three ratios i.e. R1 (10:50:40), R2 (20:50:30) and R3 (30:50:20). In all three ratios, 50% of N and S were applied at V8 stage, while 10, 20 and 30 % was applied at sowing and 40, 30 and 20% was applied at tasseling in Ratio 1, 2 and 3 respectively. A plot size of 3m x 4.9m having 7 rows 70 cm a part. A plant to plant distance of 25cm was maintained by thinning at 4-5 leaf stage. A basic dose of 120 kg P ha^{-1} and 125 kg K2O ha^{-1} was applied in the form of diammonium phosphate (DAP) and murate of potash (MOP). Nitrogen and sulfur were applied in three splits: 1st at time of sowing, 2nd at V8 (when eight leaf, ear and shoots are clearly visible) and 3rd at VT stage (when tassel is completely out). Weeding was done 40 days after sowing. Each year, wheat was grown after harvest of maize. Weeds observed in the experimental plots were *Echinochloa- crusgalli, Cyperus rotundus, Amaranthus viridis, Convolvulus arvensis, Portulaca oleracea, Digitaria* spp., *Cucumis* spp. and *Cynodon dactylon*. Metrological data was recorded at weather station located at Regional Metrological Center Peshawar (Figs. 1 & 2).

Soil analysis

Composite soil samples at 0–30 cm depths were taken from the experimental field before planting and after harvest of maize from each plot in 2011 and 2013. Soil samples were bulked and analyzed for soil texture (Koehler *et al*., 1984), soil pH (McClean, 1982), soil electrical conductivity (Black, 1965), soil organic matter (Nelson and Sommer, 1982) and soil total nitrogen (Bremner, 1982). The soil is silty clay loam in nature, alkaline in reaction (pH 8.2 and 8.1), having EC values of 0.19 and 0.25, low in organic matter (0.88 and 0.72%), and low total N content of 0.05 and 0.08% (Table-1).

Observation and measurements

Weed density (WD) data were recorded 25 days after sowing. Each time quadrate measuring 0.5 x 0.5 m^2 was placed randomly three times in each treatment. The weeds inside the quadrate were counted and identified to determine the WD. Average was calculated and then subsequently converted into m^2. Fresh and biomass of weeds (m^{-2}) 25 days after sowing quadrate was randomly thrown at three places in each treatment and the weeds inside each quadrate were harvested, weighed for fresh weight and then oven dried for 48 hours at 70 ^{0}C. Average dry weight of weeds was calculated and then was converted into m^{-2}. Similarly data on plant height was taken from base to the top of plant for 5 selected plants per subplot in all treatments. For Harvest index, Harvest index was determined by following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

The data was statistically analyzed using analysis of variance appropriate for 3-factorial treatment arrangement in randomized complete block design. Combined analysis was performed to detect the variation between the years. Means were separated using least significant difference (LSD) test at 0.05 level of probability (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Weed density

Years (Y) significantly affected weeds density (WD m^{-2}) (Table-2). Mean values for years showed that more weeds density 40 m^{-2} was observed in 2011 as compared with 2013 which produced 37 weeds m^{-2} (Table-3). Mean values for N and S levels revealed that WD (m^{-2}) did not significantly increase with each increment of N and S. Ratios also did not significantly affect the WD at 5% level of significance. The significant difference in WD over the years may be due to the high moisture availability due to more rains during 2011 (278 mm) compared to 131mm rainfall occurred in 2013 (Figs. 1 & 2). The non-significant impact of N, S and ratios might be due to the fact that germination is mostly related to the reserved food present in seed and seed utilizes its own endosperm for germination and initial growth (Shah *et al.*, 2009).

Weed biomass

Weed biomass (WB) was significantly affected by year (Y), nitrogen (N), ratios (R), control vs fertilized plots (Table-2). Maize crop planted in 2011 had more WB (78.15 g m^{-2}) compared with 77.41 g m^{-2} in 2013 (Table 4). Significantly higher WB in 2013 may be due to the high moisture availability because of more rains during 2011 (278 mm) compared to 131mm rainfall occurred in 2013 (Fig. 2). The mean values for N levels revealed that maximum WB (83.0 g m^{-2}) was observed with the application of N@240 kg ha^{-1}. While lowest WB (74.8 g m^{-2}) was recorded for N@120 kg ha^{-1}. The increase in WB may be due to nitrogen which enhances vegetative growth of crop. Our results are in line with Amanullah *et al.* (2009), Azeem *et al.* (2014), Nawaz (1989) and Khaliq *et al.* (2009) who reported that application of N enhances vegetative growth. Ratios mean values showed that more WB (79.9 g m^{-2}) was recorded at R3 (30:50:20) compared with R2 and R3. This may be due to the reason that in R3 30% of the required fertilizer dose was applied at the time of sowing compared to 20% in R2 and 10% in R1. R3 received three times more N so weeds in R3 had more nutrients available for uptake and had more vegetative growth compared with R2 and R1. Our results are in line with Ampong-Nyarko and De Datta (1993) who reported that fertilizer may benefit weed growth to a greater extent than crop growth.

Plant height

Year (Y), nitrogen (N), sulfur (S) and control vs fertilized had significant effect on plant height (PH) (Table-2). Taller (186 cm) were produced in the 2013 while shorter plants (178 cm) were produced in 2011 (Table 5). Plants were taller (192 cm) in the plots treated with N@240 kg ha^{-1}followed by (191 cm) PH of the plots with N@200 kg ha^{-1}, while PH was lowest (183 cm) in the plots treated with N@120 kg ha^{-1}. Taller plants (190 cm) were recorded with application of S@35 kg ha^{-1} whereas minimum PH (185 cm) was observed with S@20 kg ha^{-1}. Greater PH (187 cm) was observed in fertilized plots as compared to control plots (177 cm). The significant difference in PH over the years may be due to the loss of nutrient by leaching through heavy rainfall in 2011 (278 mm) compared to 131mm rainfall occurred in 2013 (Figure 2).The increase in PH in response to application of highest N dose is probably due to enhanced availability of N which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Azeem *et al*., 2014). Similarly nitrogen enhances vegetative growth therefore produces taller plants, our results are at par with Banziger *et al.* (1999) who reported that plant height increase with increase of N levels. Taller plant at higher S levels might be due to the reason that sulfur has the ability to decrease pH of the soil and provide a favorable environment to plant for higher nutrients uptake and make synergistic effect with nitrogen for development of plant. Dev and Kumar (1982) reported higher S uptake improves N uptake and thus improves maize plant growth. Sulfur deficiency causes profound changes in N metabolism with reduced protein synthesis and accumulation of soluble organic and inorganic nitrogenous compounds (Charliers and Carpenter, 1956). Taller plants in fertilized plots may be due to more nutrients availability as compared to control. Our results are at par with Azeem *et al*. (2014) who reported that taller plants were observed in fertilized plots compared to control.

Harvest index

Harvest index (HI) as affected by various nitrogen, sulfur and ratios is presented in Table-6. Year (Y), nitrogen (N), sulfur (S), ratios (R) and control vs fertilized plots significantly affected HI (Table-2). Mean data showed that higher HI (39.84) was observed in 2013 as compared to 2011 (38.93) (Table-5). Max HI (41.28) was observed N@200 kg ha^{-1} while with N@240 kg ha^{-1} HI (36.05) decreased. In case of S with HI (39.34) was lowest with S@20 kg ha^{-1} and with maximum S@35 kg ha^{-1} maximum HI (39.81) was observed. Regarding ratios mean data revealed that greater HI (39.78) observed with R3 (30:50:20) compared to lower HI (39.45) in R1 (20:50:30). This may be due to the reason that R3 received three times more N and S compared to R1 at the time of sowing. Due to availability if more N the weeds in RS had more nutrients available for uptake and had more growth compared with R2 and R1. The control vs fertilized plots showed that control plot had less HI (37.23) as compared to rest plots (39.57). Our results are in line with Monasterio *et al*. (1997) who also reported that because of optimum utilization of solar light, higher assimilates production and its conversion to starches resulted higher grains weight that resulted more biomass and seed yield (Derby *et al*., 2004). Yield and yield components were significantly increased by nitrogen levels (El-Sheikh, 1998). High HI at high S levels may be due to the fact that sulfur decreases pH of soil which increases nutrients uptake. These results agree with Khan *et al.* (2006) and Sakal *et al.* (2000) who reported that higher doses of S enhances grain yield which ultimately improves Harvest index.

CONCLUSION

Application of 200 kg N ha^{-1}, 35 kg S ha^{-1} applied in ratio of 30% at sowing, 50% at V8 and 20% at VT stage is recommended for controlling weeds and obtaining higher HI of maize hybrid Babar.

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Table-1: Pre-sowing physico-chemical properties of soil (0-30 cm depth)

Property	Unit	2011	2013	Mean
Clay	%	28.1	32.89	31.23
Silt	″	50.3	53.3	51.5
Sand	″	21.6	13.81	17.23
Textural class	---	Silty clay loam	Silty clay loam	Silty clay loam
pH (1: 5)	---	8.2	8.1	8.1
EC (1: 5)	d S m^{-1}	0.19	0.25	0.22
Organic matter	%	0.88	0.72	0.81
Total nitrogen	″	0.05	0.08	0.08

Table-2: Analysis of variance of WD (m^{-2}), weeds dry matter (g m^{-2}), plant height (cm) and harvest index (%) as affected by N, S, ratios over the years

SOV	DF	Weeds Density (m^{-2})	Weeds dry matter (g m^{-2})	Plant Height (cm)	Harvest Index (%)
Year (y)	1	*	**	**	**
Rep	4	Ns	ns	ns	Ns
Treatment (T)	48	Ns	**	**	**
Nitrogen (N)	(3)	Ns	**	**	**
Sulfur (S)	(3)	Ns	ns	*	*
Ratio (R)	(2)	Ns	*	ns	*
N x S	(9)	Ns	ns	ns	Ns
N x R	(6)	Ns	ns	ns	Ns
S x R	(6)	Ns	ns	ns	Ns
N x S x R	(18)	Ns	ns	ns	Ns
Control vs. Rest	(1)	Ns	**	**	**
Y x T	48	Ns	ns	ns	Ns
Y x N	(3)	Ns	ns	ns	Ns
Y x S	(3)	Ns	ns	ns	Ns
Y x R	(2)	Ns	ns	ns	Ns
Y x N x S	(9)	Ns	ns	ns	Ns
Y x N x R	(6)	Ns	ns	ns	Ns
Y x S x R	(6)	Ns	ns	ns	Ns
Y x N x S x R	(18)	Ns	ns	ns	Ns
Y x cont vs. rest	(1)	Ns	ns	ns	Ns
Error	192				
CV%		7.60	5.21	5.81	9.06

*= Significant at 5% probability level, **= Significant at 1% probability level
ns= Non significant

Table-3: Weeds Density (m^{-2}) of maize hybrid "Babar" as affected by nitrogen (N), sulfur (S) and ratios (R) over the years.

N (kg ha^{-1})	Year		Mean
	2011	2013	
120	40.9	37.6	39.2
160	40.7	37.3	39.0
200	40.5	37.6	39.0
240	40.5	37.5	39.0
LSD$_{0.05}$			
S (kg ha^{-1})			
20	40.8	37.9	39.3
25	40.8	37.3	39.0
30	40.3	37.4	38.8
35	40.7	37.3	39.0
LSD$_{0.05}$			
Ratios			

R1 (10:50:40)*	40.3	38.2	39.2
R2 (20:50:30)	41.0	37.0	39.0
R3 (30:50:20)	40.6	37.2	38.9
$LSD_{0.05}$			
Control vs. rest			
Control	38.33	36.67	37.50
Rest	40.64	37.48	39.06
Mean	40.46a	37.41b	

Means in the columns having different alphabets are significantly different (at 0.05% level of significance).
*10, 20 and 30% of N and S were applied at sowing 50% of N and S were applied at V8 while and 40, 30 and 20% were applied at tasseling in Ratio 1, 2 and 3.

Table-4: Weeds biomass (g m^{-2}) of maize hybrid "Babar" as affected by nitrogen (N), sulfur (S) and ratios (R) over the years.

	Year		Mean
N (kg ha^{-1})	2011	2013	
120	76.7	72.9	74.8d
160	78.4	77.1	77.8c
200	81.9	82.0	81.9b
240	83.2	82.7	83.0a
$LSD_{0.05}$			1.4
S (kg ha^{-1})			
20	80.7	77.5	79.1
25	81.1	76.3	78.7
30	80.3	80.7	80.5
35	78.0	80.2	79.1
$LSD_{0.05}$			
Ratios			
R1 (10:50:40)*	79.0	78.3	78.6b
R2 (20:50:30)	80.9	78.2	79.5a
R3 (30:50:20)	80.3	79.6	79.9a
$LSD_{0.05}$			1.2
Control vs. rest			
Control	55.33	61.91	58.62b
Rest	80.05	78.70	79.38a
Mean	78.15a	77.41b	

Means in the columns having different alphabets are significantly different (at 0.05% level of significance).
*10, 20 and 30 % of N and S were applied at sowing 50% of N and S were applied at V8 while and 40, 30 and 20% were applied at tasseling in Ratio 1, 2 and 3.

Table-5: Plant height (cm) of maize hybrid "Babar" as affected by nitrogen (N), sulfur (S) and their ratios (R) over the years.

N (kg ha^{-1})	Year		Mean
	2011	2013	
120	183	182	183b
160	185	183	184b
200	187	194	191a
240	190	194	192a
$LSD_{0.05}$			3.563
S (kg ha^{-1})			
20	183	187	185b
25	184	188	186b
30	187	188	188b
35	190	190	190a
$LSD_{0.05}$			3.563
Ratios			
R1 (10:50:40)*	185	186	185
R2 (20:50:30)	186	188	187
R3 (30:50:20)	188	191	189
$LSD_{0.05}$			
Control vs. rest			
Control	176	178	177b
Rest	186	188	187a
Mean	178b	186a	

Means in the columns having different alphabets are significantly different (at 0.05% level of significance).

*10, 20 and 30% of N and S were applied at sowing 50% of N and S were applied at V8 while and 40, 30 and 20% were applied at tasseling in Ratio 1, 2 and 3.

Table-6: Harvest index (%) of maize "Babar" as affected by nitrogen (N), sulfur (S) and their ratios (R) over the years.

N (kg ha^{-1})	Year		Mean
	2011	2013	
120	40.15	40.51	40.33c
160	40.08	41.12	40.60b
200	40.79	41.77	41.28a
240	35.26	36.85	36.05d
$LSD_{0.05}$			0.19
S (kg ha^{-1})			
20	38.89	39.79	39.34b
25	38.91	40.04	39.47b
30	39.14	40.16	39.65ab
35	39.34	40.28	39.81a
$LSD_{0.05}$			0.19
Ratios			
R1 (10:50:40)*	38.86	40.05	39.45b
R2 (20:50:30)	38.96	39.98	39.47b

R3 (30:50:20)	39.39	40.17	39.78a
LSD			0.16
Control vs. rest			
Control	37.28	37.17	37.23b
Rest	39.07	40.07	39.57a
Mean	38.93b	39.84a	

Means in the columns having different alphabets are significantly different (at 0.05% level of significance).

*10, 20 and 30 % of N and S were applied at sowing 50% of N and S were applied at V8 while and 40, 30 and 20% were applied at tasseling in Ratio 1, 2 and 3.

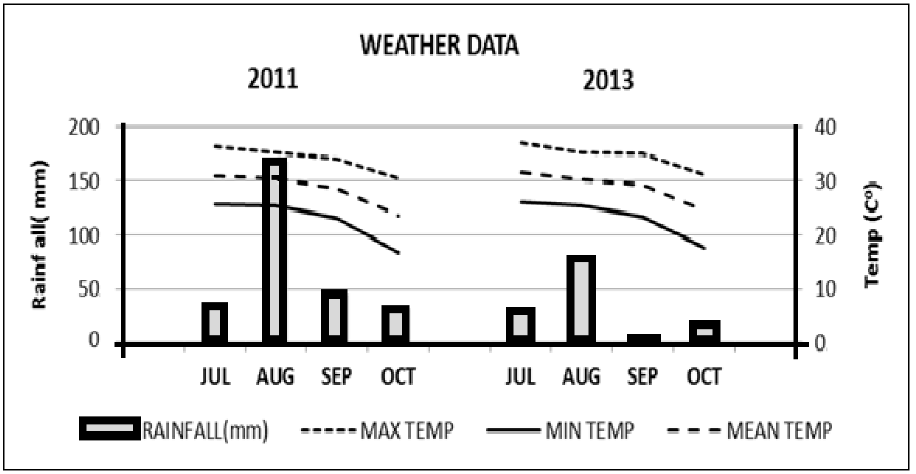

Figure 1. Monthly rainfall recorded during 2011 and 2013 in maize growing season

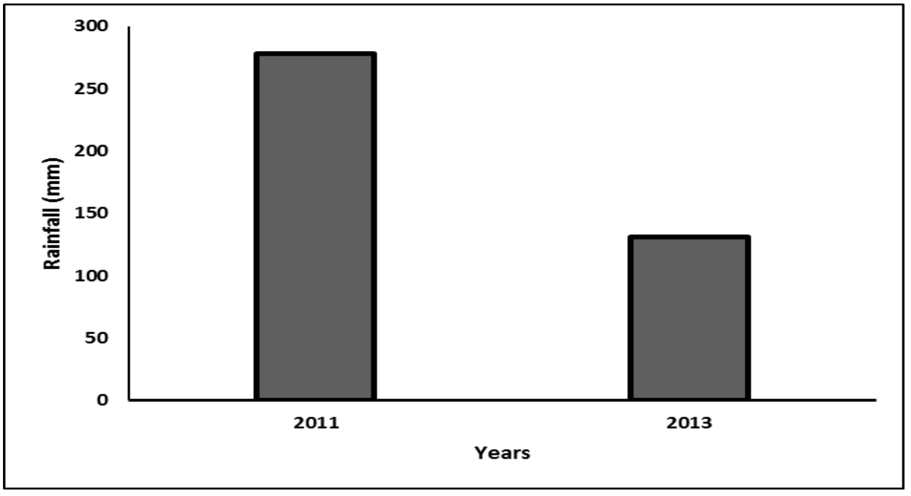

Figure 2. Total rainfall in 2011 and 2013 in maize growing season

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