

GROWTH AND YIELD COMPONENTS OF SESAME (*Sesamum Indicum* L.) AS INFLUENCED BY PHOSPHORUS LEVELS UNDER DIFFERENT ROW SPACING

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ABSTRACT
The objective of this study was to determine the effects of phosphorus (P) levels and row spacings on yield and yield components of sesame (*Sesamum indicum* L.). The field experiment was carried out at New Developmental Farm of The University of Agriculture, Peshawar, Pakistan during summer 2013. The experiment was laid out in randomized complete block design with four replications. The treatments were four row spacings (30, 40, 50 and 60 cm) and four P levels (0, 70, 100 and 130 kg ha^{-1}) in the form of SSP were used. Plots treated with 100 kg P ha^{-1} produced maximum capsule length (2.66 cm), capsules plant^{-1} (82), seeds capsule^{-1} (60), 1000 seeds weight (3.64 g), seed yield (770 kg ha^{-1}), biological yield (4084 kg ha^{-1}) and harvest index (18.85 %) as compared with control plots. Row to row distance 60 cm had significantly maximum capsule length (2.57 cm), capsules plant^{-1} (81), seeds capsule^{-1} (56), 1000 seeds weight (3.42 g), seed yield (681 kg ha^{-1}), biological yield (4197 kg ha^{-1}) and harvest index (16.23 %) as compared with the other row spacings. It was concluded that application of P at the rate of 100 kg ha^{-1} with row spacing 60 cm could improve yield and yield components of sesame in the agro-climatic conditions of Peshawar valley.
Key Words: (*Sesamum indicum* L.), *row spacing, phosphorus levels, seed yield, yield components*

INTRODUCTION

Sesame (*Sesamum indicum* L.) member of the order tubiflera, family Pedaliaceae is a short-day plant mostly grown in the tropical and subtropical area over the world. Sesame is considered as a drought tolerant crop and is therefore mainly grown as dry land crop especially in Indian sub continent. In Pakistan, sesame was cultivated on an area of 77.6 thousand hectares with an annual production of 31 thousand tonnes and an average yield of 401 kg ha^{-1} in Pakistan whereas in Khyber Pakhtunkhwa its average yield is 568 kg ha^{-1} (MINFA, 2012). It is a good source of vitamins and minerals such as calcium and phosphorous and the seed cake is also an important nutritious livestock feed (Malik *et al.,* 2003). The seeds also contain high quality of edible oil (43-55%) and its oil has high degrees of stability and resistance to rancidity. (Alpaslan *et al.,* 2001). Ahmed *et al.,* 1997 reported that the application of phosphorus plays a vital role in the formation and translocation of carbohydrates, root development, crop maturation and resistance to disease pathogens. It significantly increases seeds pod^{-1}, pods plant^{-1}, seed yield, oil and protein content of sesame cultivar. Supply of Phosphorus is usually associated with increased root density and proliferation, which aid in extensive exploration and supply of nutrients and water to the growing plant parts, resulting in increased growth and yield traits, there by ensuring more seed and dry matter yield (Shehu *et al.,* 2010). Application of 90 kg P ha^{-1} significantly increased growth, yield and yield attributes in Nigeria (Olowe and Busari, 2000). Application of 100 kg P ha^{-1} significantly increased the number of leaves plant^{-1}, number of seeds pod^{-1} and seed yield ha^{-1} (Okpara *et al*., 2007). Hafiz et al. 2012 reported that the application of phosphorus rate increased from 57 to 76 and then to 95 kg ha^{-1}, the yield components also showed positive response to the higher rate of phosphorus 95 kg ha^{-1}. Row spacing is one of the important components in intensive farming system that could bring a positive increase in yield. Due to proper space plants can receive sufficient sun light, water and other necessary nutrients from the soil which enhance the yield of the sesame. Ngala et al. 2013 reported that 75 cm row spacing produced the higher seed yield as compared with 25 cm and 50 cm row spacing. Wider row spacing showed more potential for high seed yield as compared to narrow row spacing. Very narrow row spacing increases the site-specific compactions between the plants resulting a lower grain yield. Christo and Onuh (2005) reported that there was significant difference between row spacing 30 cm and 60 cm. 60cm row spacing led to increase in seed yield and the highest yield 1620 kg ha^{-1} was obtained from row spacing 60 cm. Keeping in view the restrictions under rainfed condition this experiment was conducted under irrigated intensive agricultural conditions. To find out the most suitable phosphorus levels and row to row distance for higher yield in the agro-climatic condition of Peshawar.

MATERIALS AND METHODS

This research was carried out at New Developmental Farm of The University of Agriculture, Peshawar (34^o 00' N, 71^o 30' E, 510 MASL) Pakistan during kharif 2013. The experiment was laid out in randomized complete block design with four replications. The treatment consisted of four row spacings (30, 40, 50 and 60 cm) and four levels of phosphorus (0, 70, 100 and 130 kg ha^{-1}) in the form of SSP were used.
The area of sub plot for each row apace was:
For 30 cm row space: 1.8 x 4 m
For 40 cm row space: 2.4 x 4 m
For 50 cm row space: 3.0 x 4 m
For 60 cm row space: 3.6 x 4 m
Nitrogen in the form of urea was applied at the rate of 60 kg ha^{-1}, half dose was applied at sowing time and the remaining half was applied at flowering stage. Crop was sown in the 3rd week of June at seed rate of 4 kg ha^{-1} using sesame cultivar local black and harvested in 2nd week of November 2013. After harvesting capsule length (cm) of ten capsules randomly selected capsule was measured with measuring tape. Number of capsule plant^{-1} was counted for ten plants selected randomly in each subplot. Seeds capsule^{-1} was recorded by counting seed in ten capsules selected randomly in each sub plot. After crop threshing data from thousand seeds weight (g) were recorded for three seed lots and weighed with the help of electronic balance. For grain yield and biological yield four central rows in each sub plot were harvested, sun dried and threshed and then converted into kg ha^{-1}.

$$\text{Seed yield (kg ha}^{-1}) = \frac{\text{Seeds weight in four rows (kg)}}{\text{No of rows x Row length x R-R}} \times 10{,}000 \text{ m}^2$$

Harvest index was calculated by using the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Data collected were analyzed statistically according to the procedure relevant to RCB design. Upon significant F-Test, least significance difference (LSD) test was used for mean comparison to identify the significant components of the treatment means (Jan et al., 2009).

RESULTS AND DISCUSSION

Capsule length (cm)

Statistical analysis of the data indicated in table 1 that phosphorus levels and row spacing had significant effect on capsule length while the interaction between P x R had not significant effect on capsule length. Capsule length was increased with increase in phosphorus levels up to 100 kg ha^{-1} further increase in phosphorus slightly reduce in capsule length. Mean value of the phosphorus level indicated that plot treated with 100 kg ha^{-1} produced maximum (2.66 cm) capsule length while the lowest (2.23 cm) capsule length was recorded in control plots. These results agree with (Shehu et al. 2010) who reported that significant differences in capsule length were recorded among phosphorus levels. Minimum (2.20 cm) capsule length was recorded in control plots when phosphorus levels were enhanced from 0 to 120 kg ha^{-1}, capsule length increased from 2.20 cm to 2.81 cm. Mean value of row spacing showed that maximum (2.57 cm) capsule length recorded in 60 cm row spacing, while the minimum (2.39 cm) capsule length were recorded when crop was sown at 30 cm row spacing. These results agree with those of (Kathiresan 2002) who reported that increase in row spacing decreased intraspecific competition and proper adjustment of plants in the field which facilitated more aeration and penetration of light which eventually caused increase in capsule length as compared to narrow row spacing.

Number of capsule plant^{-1}

Data presented in Table 1 indicated that the levels of phosphorus and row spacing had significant effect on number of capsules plant^{-1}. Mean values of data indicated that plots treated with 100 kg P ha^{-1} produced maximum (82) number of capsules plant^{-1} while minimum (61) number of capsules plant^{-1} was recorded in control plots. These results agree with (Ahmed *et al.,* 1997) who reported that P induced significant increased in capsules plant^{-1}. In control plots number of pods varied from 50 to 57 pods plant^{-1} and increased gradually from 75 to 90 pods plant^{-1} when phosphorus applied up to 95 kg ha^{-1}. Row spacing had also significant effect on number of capsules plant^{-1}. Maintain 60 cm row spacing produces more (81) number of capsules plant^{-1} while lowest (60) number of capsules plant^{-1} produce by narrow 30 cm row spacing. Similar results were reported by Singh and yadav (1987) who studied that increase in number capsule plant^{-1} might be attributed to wider row spacing and less inter or intra plant competition in the community as compared to narrow row spacing. Interaction between P x R indicated by Fig. 1 that all row spacing produced maximum number of capsules plant^{-1} with increasing phosphorus level up to 70 kg ha^{-1}. Exponential increases in capsules plant^{-1} were observed in plots sown in 60 cm row spacing at rate of 100 kg P ha^{-1} and the curve remained almost flat at higher level of P.

Number of seeds capsule^{-1}

Statistical analysis of the data indicated in table 1 that phosphorus levels and row spacing had significant effect on number of seeds capsule^{-1}. Seeds capsule^{-1} were increased with increase in phosphorus levels up to 100 kg ha^{-1} further increase in phosphorus slightly reduce in number of seeds capsule^{-1}. Mean value of the phosphorus level indicated that plot treated with 100 kg ha^{-1} produced maximum (60) number of seeds capsule^{-1} while the lowest (41) seeds capsule^{-1} was recorded in control plots. Similar notations were reported by Malik et al. (2003) that significant differences in number of seeds capsule^{-1} were recorded among P levels. Less (37) number of seeds capsule^{-1} were noted in control plots when phosphorus levels were enhanced from 0 to 100 kg ha^{-1}, number of seeds increased from 37 to 64 capsule^{-1}. Maintaining 60 cm row spacing produced maximum (56) number of seeds capsule^{-1} while minimum (45) seeds capsule^{-1} produced by narrow 30 cm row spacing. These results agree with those of (Kathiresan 2002) who reported that decrease in row spacing increased intraspecific competition which eventually caused reduction in the number of seeds capsule^{-1} as compared to wider row spacing. Interaction between P x R indicated by Fig. 2 that all row spacing produced maximum number of seeds capsule^{-1} with increasing phosphorus level up to 70 kg ha^{-1}. Sharp increases in capsules plant^{-1} produced when maintain 60 cm row spacing at 100 kg P ha^{-1} further increase in phosphorus level slight decrease in seeds capsule^{-1} was recorded.

Thousand seeds weight (g)

Mean values of row spacing indicated in table 1 that the maintain 60 cm row spacing produced heavier (3.42 g) seed weight while the minimum (3.03 g) seed weight was recorded by narrow 30 cm row spacing. These results agrees with those of (Olowe and Busari, 2003) who reported that 1000-seed weight was found to be higher with wider row spacing as compared to narrow row spacing. It could be due to higher plant population which reduces the seed size. Plots treated with 100 kg P ha^{-1} produced heavier (3.64 g) seed weight, followed by 130 kg P ha^{-1} produced (3.35 g) seed weight while minimum seed weight (2.79 g) was recorded in control plots. These results agree with those of (Hafiz *et al.,* 2012) who reported that increasing phosphorus application significantly increased the seed weight. Interaction between P x R indicated by Fig. 3 that all row spacing produced maximum 1000 seeds weight with increasing phosphorus level up to 100 kg ha^{-1}.and level off at 130 kg P ha^{-1} in all the row spacing.

Seed yield (kg ha^{-1})

Mean value of phosphorus levels indicated in table 1 that plots treated with 100 kg ha^{-1} produced maximum (770 kg ha^{-1}) seed yield while the minimum (433 kg ha^{-1}) seed yield was recorded in control plots. These results agrees with those of (Hafiz *et al.,* 2012) who reported that yield increased with the increase in P level up to 95 kg ha^{-1} Higher level than that did not increased seed yield. The effect of row spacing had also significant effect on seed yield. Plots having a row spacing of 60 cm attained 681 kg seed yield ha^{-1} while lowest seed yield of 484 kg ha^{-1} was recorded by narrow row spacing (30 cm). These results are in agreement with (Olowe and Busari 2003) who reported that wider row spacing showed more potential to realize high seed yield than the closest spacing. Increase in seed yield at wider row spacing may be due to larger space and growth resources available per individual plant, which enhanced growth and development. The decrease in seed yield at narrow spacing could have resulted from the higher inter and intra plant competition for growth resources. The interaction between P x R indicated by Fig. 4 that all row spacing produced maximum seed yield when increasing phosphorus level up to 70 kg ha^{-1}. But a linear increase was recorded for seed yield when the sesame cultivar was sown at 60 cm row spacing and treated with 100 kg P ha^{-1}. However further increase in phosphorus level slight decrease in seed yield was recorded.

Biological yield (kg ha^{-1})

Statistical analysis of biological yield showed in table 1 that phosphorus levels and row spacing had significant effect on biological yield while the interaction between P x R was not significant. Plots supplied with phosphorus had significantly higher biological yield as compared to control plots. With the increase of phosphorus level biological yield increasing significantly and therefore the highest level of phosphorus (100 kg ha^{-1}) produced the maximum biological yield (4084 kg ha^{-1}) while lowest (3310 kg ha^{-1}) biological yield was recorded in control plots. These results agree with the findings of (Hafiz *et al.,* 2012) who reported that increasing rate of phosphorus application significantly increased biological yield over control plots. Sesame sown with 60 cm row spacing recorded maximum (4191 kg ha^{-1}) biological yield as compared to 30 cm row spacing produced minimum (3134 kg ha^{-1}) biological yield. These results are in agreement with (Olowe and Busari 2003) who reported that wider row spacing showed more potential to realize high biological yield as compared to narrow row spacing. Increase in biological yield at wider row spacing may be due to larger space and growth resources available per individual plant which enhanced growth and development.

Harvest index (%)

Statistical analysis of harvest index showed in table 1 that phosphorus and row spacing had significant effect on harvest index while the interaction between P x R was not significant. Plots supplied with phosphorus had significantly higher harvest index as compared to control plots. With the increase of phosphorus level harvest index increasing significantly and therefore the highest level of phosphorus (100 kg ha^{-1}) produced the maximum harvest index (18.85 %) while lowest (13.08 %) harvest index was recorded in control plots. These results agree with the findings of (Shehu et al. 2010) who reported that increasing rate of phosphorus application significantly increased harvest index over control plots. Sesame sown with 60 or 50 cm row spacing recorded maximum (16.23 %) harvest index as compared to narrow 30 cm row spacing produced (15.44 %) harvest index. These results were similar to those reported by (Olowe and Busari 2003) who reported that maximum (19 %) harvest index was recorded in wider row spacing as compared to narrow row spacing.

Table I. Capsule length (cm), capsules plant^{-1}, seeds capsule^{-1}, thousand seeds weight (g), seed yield (kg ha^{-1}), biological yield (kg ha^{-1}) and biological yield (%) of sesame as affected by phosphorus levels and row spacing's

Treatment	Capsule length (cm)	Capsules plant^{-1}	Seeds capsules^{-1}	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	H.I (%)
Phosphorus (kg ha^{-1})							
0	2.23d	61d	41d	2.79d	433d	3310d	13.08d
70	2.44c	66c	46c	3.17c	490c	3537c	13.85c
100	2.66a	82a	60a	3.64a	770a	4084a	18.85a
130	2.51b	71b	55b	3.35b	620b	3722b	16.66b
LSD (0.05)	0.04	0.27	0.52	0.02	7.22	10	0.59
Row spacing (cm)							
30	2.39d	60d	45d	3.03d	484d	3134d	15.44b
40	2.47c	67c	49c	3.17c	543c	3462c	15.68ab
50	2.52b	73b	52b	3.28b	605b	3759b	16.09a
60	2.57a	81a	56a	3.42a	681a	4197a	16.23a
LSD (0.05)	0.04	0.27	0.52	0.02	7.22	10	0.59
Interaction							
P x R	ns	*	*	*	*	ns	ns

Means in the same category followed by different letters are significantly different at P ≤0.05 levels. ns = non-significant

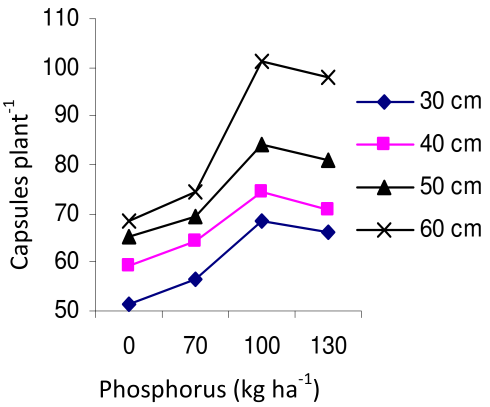

Fig. 1. Capsules plant^{-1} of sesame is affected by row spacing's and phosphorus levels.

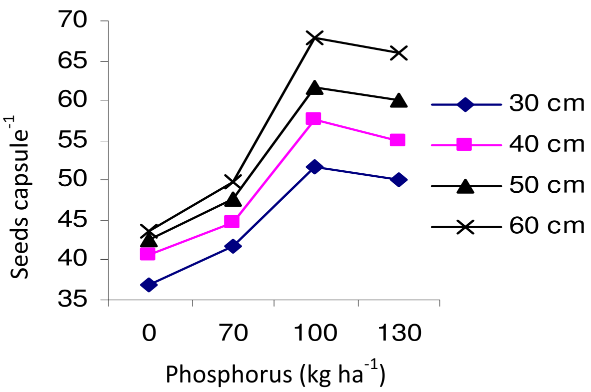

Fig. 2. Seeds capsule^{-1} of sesame is affected by row spacing's and phosphorus levels.

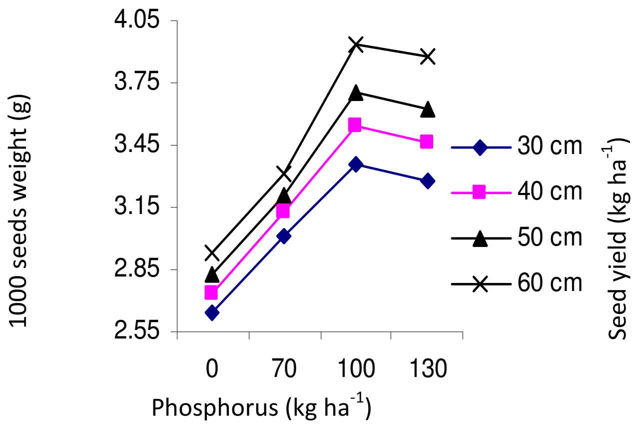

Fig. 3. 1000 seed weight of sesame is affected by row spacing's and phosphorus levels.

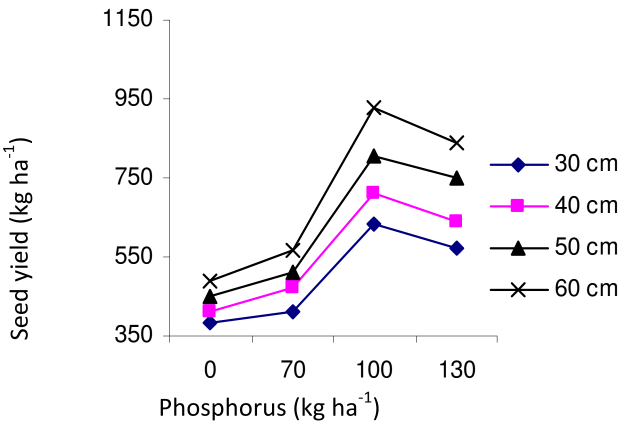

Fig. 4. Seeds yield of sesame is affected by row spacing's and phosphorus levels.

CONCLUSION AND RECOMMENDATIONS

It was concluded from present research work that supplied phosphorus at the rate of 100 kg ha^{-1} with 60 cm row spacing produced maximum capsules plant^{-1}, seeds capsule^{-1}, 1000 seeds weight, seed yield, biological yield and harvest index. Therefore, it is recommended that under the Peshawar valley condition sesame should be sown in row to row distance 60 cm supplied with 100 kg P ha^{-1} at the time of sowing for higher seed yield.

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