

Effect of Tillage Systems, Irrigation Intervals and Phosphorus Levels on Oil Content, Yeild and Yeild Components of Sesame

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ABSTRACT
Despite the importance of sesame (Sesamum indicum L.) in the world, this crop has received only little research attention in Pakistan. Therefore, a field experiment was carried out to evaluate the performance of tillage system under various phosphorus levels and irrigation intervals at New Developmental Farm of The University of Agriculture, Peshawar, Pakistan during summer 2012. The experiment was laid out in randomized complete block design with split plot arrangement having three replications. Irrigation interval (9 days, 18 days and 27 days) and tillage system (conventional tillage with cultivator, deep tillage with chisel plough and shallow tillage with MBP) were allotted to main plots, while phosphorus levels (0, 30, 60 and 90 kg ha^{-1}) were allotted to sub plots. Irrigation interval had significantly affected all the parameters except oil content. Water supply at 9 days interval had maximum capsules plant^{-1} (63), seed capsule^{-1} (59), 1000 seed weight (3.61 g), oil yield (515 kg ha^{-1}), seed yield (975 kg ha^{-1}) and biological yield (6642 kg ha^{-1}) as compared with other irrigation intervals. Tillage system had significantly affected all the parameters except oil content. Conventional tillage produced maximum capsules plant^{-1} (59), seed capsule^{-1} (53), 1000 seed weight (3.38 g), oil yield (505 kg ha^{-1}), seed yield (949 kg ha^{-1}) and biological yield (6054 kg ha^{-1}) as compared with deep and shallow tillage system. Phosphorus application had significantly affected all parameters. Plots treated with 90 kg P ha^{-1} produced maximum capsules plant^{-1} (71), seed capsule^{-1} (62), 1000 seed weight (4 g), oil content (58.21 %) oil yield (676 kg ha^{-1}), seed yield (1160 kg ha^{-1}) and biological yield (6684 kg ha^{-1}) as compared with control plots. The interaction between tillage systems, irrigation intervals and phosphorus levels revealed that application of water at 9 days interval with conventional tillage method and treated with 90 kg P ha^{-1} had maximum capsules plant^{-1}, 1000 seed weight, oil yield, seed yield and biological yield. Conventional tillage with 9 days irrigation interval and treated with 90 kg P ha^{-1} seems to be the best choice for sesame grower in the agro-climatic condition of Peshawar valley.
Keywords:*Sesame (Sesamum indicum* L.*), tillage systems, irrigation intervals, phosphorus levels, oil content, oil 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 tones and an average yield of 401 kg ha^{-1} in Pakistan whereas in Khyber Pakhtunkhwa its average yield was 1000 kg ha^{-1} (MINFA, 2011). 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 crop also contains high quality of edible oil (43–55%) and its oil has high degrees of stability and resistance to rancidity. (Alpaslan *et al.,* 2001). Enhanced in sesame production, soil porosity is improved by conventional tillage practices and incorporation of residues (Dinnes *et al.,* 2002). With improvement in porosity the aeration is enhanced which ensures adequate availability of oxygen to the plant root. Deep tillage practices improved root length and moisture availability as compared to shallow tillage. Deep tillage significantly increased the plant height and grain yield of sesame (Bahadar *et al.,* 2007). Many researchers have found that the conventional tillage operations disturb more soil that generally increases soil aeration, residue decomposition and breakdown, organic P mineralization and the availability of P for crop use (Dinnes *et al.,* 2002) but in contrast, under zero-tillage soil is not disturbed that increases the build-up of surface residue, which in turn increase nitrogen immobilization decreases its loss through leaching and results in denitrification (Bahadar *et al.,* 2007). Conventional tillage farming systems has been shown to improve crop establishment and growth through the amelioration of the adverse effects of high soil temperature, soil crusting and rapid drying of the soil surface. (Bulent *et al.,* 2012). Recently, reduced and no-till methods have gained popularity. The employment of no-till or reduced tillage has been shown to be economical, useful for soil aggregation, and helpful in reducing soil erosion (Polat *et al.,* 2006). Water stress significantly decreased seed yield plant^{-1} in sesame but it did not influence its seed weight plant^{-1} water deficit significantly affected the yield of auxiliary branches in sesame, so that its yield was higher under normal conditions as compared to under water stress conditions. To obtain optimum yield, it is necessary to supply enough moisture by irrigation in addition to improving soil fertility (Jouyban *et al.,* 2011). Karaaslan *et al.,* 2007 showed that extending the irrigation interval from 6 to 24 days decreased sesame yield from 1790 to 1130 kg ha^{-1}, respectively. Water stress is the most important factor affecting seed yield, especially in arid and semi arid regions. Sesame is one of the most important edible seeds in conventional farming in tropical and subtropical regions. 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. Thus increase significantly 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). Keeping in view the limitations under rainfed condition this experiment was conducted at the irrigated condition under the intensive farming system to find out the most suitable tillage system, irrigation interval and phosphorus levels for higher yield at 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 2012. The experiment was carried out in randomized complete block design with split plot arrangement having three replications. Tillage systems (conventional tillage (CT) (15 cm) depth with cultivator, deep tillage (DT) (45 cm) depth with chisel plough and shallow tillage (ST) (30 cm) depth with mould board plough (MBP)) and irrigation intervals (9 days, 18 days and 27 days) were allotted to main plots, while phosphorus levels (0, 30, 60 and 90 kg ha^{-1}) were allotted to sub plots in the form of SSP. A sub plot size of 4 m x 3 m was used. Each sub plot consisted of 10 rows having 40 cm row-to-row distance. 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 October 2012. Number of capsule plant^{-1} was counted in ten plants selected randomly in each subplot. Seed capsule^{-1} was recorded by counting seed in ten capsules randomly selected. Thousand seed weight (g) were recorded from three seed lot and weight with the help of electronic sensitive 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}.

Seed oil content (%) was determined by using Soxhlet apparatus and n-hexane (60ºC) as an extraction solvent according to A.O.A.C. (1980).

Oil yield was calculated by following formula.

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{oil content \% x seed yield (kg ha}^{-1}\text{)}}{100}$$

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

Table a. Temperature (C°), rainfall (mm) and relative humidity (%) experimental site for the growing period of the sesame crop (June-October 2012)

Month	Mean temperature (C°)		Mean rainfall (mm)	R.H (%)
	Minimum	Maximum		
June	22	43	0	35
July	27	41	80	56
August	26	38	100	59
September	23	35	0	70
October	15	31	56	56

RESULTS AND DISCUSSION

Number of capsules plant^{-1}

Mean value of irrigation interval revealed in table 1 that with increasing irrigation interval capsule plant^{-1} drastically decrease and maximum (63) number of capsule plant^{-1} produced from 9 days irrigation interval which was (37 %) greater from 27 days irrigation interval. These results are in agreement with the findings of Jouyban *et al.,* (2011) who reported that (53%) reduction in capsules plant^{-1} with increasing irrigation interval from 6 to 18 days this might have been due to abscission of flowers and pods under moisture stress. Tillage system had significant effect on number of capsule plant^{-1}. Maximum (59) number of capsule plant^{-1} was recorded in CT system while minimum (52) number of capsule plant^{-1} was noted in ST system. Similar results were reported by Bulent *et al.,* (2012) who found that (20%) reduction in capsule plant^{-1} by shallow tillage when compared to conventional tillage system. Plot treated with 90 kg P ha^{-1} produced (71) number of capsule plant^{-1} while 36 capsule plant^{-1} was recorded in control plots. These results are in line with those of Shehu et al. (2010) who reported that capsule plant^{-1} increased with increase of P level up to 95 kg ha^{-1} and this might be associated with increased root density and proliferation, which aid in extensive exploration and supply of nutrients and water to crop. Interaction between T x I x P indicated in (Fig. 1) that number of capsule plant^{-1} increased with increasing P levels in all irrigation interval and tillage system but maximum number of capsule plant^{-1} was recorded from 9 days irrigation interval with CT system and treated with 90 kg P ha^{-1}.

Number of seeds capsule^{-1}

Maximum (59) number of seeds capsule^{-1} produced from 9 days irrigation interval was (41 %) greater than 27 days irrigation interval. These results are in line with those of Karaaslan *et al.*, (2007) who reported decreased (43%) seeds capsule^{-1} with increasing irrigation interval from 7 to 21 days. Tillage system had significant effect on number of seeds capsule^{-1}. Maximum (53) number of seeds capsule^{-1} was recorded in CT while minimum (48) number of seeds capsule^{-1} was noted in ST. These results agree with those of Yol *et al.,* (2010) who obtained higher (70) number of seeds capsule^{-1} when conventional tillage system was applied as compared to deep and shallow tillage practices. Plot treated with 90 kg P ha^{-1} produced 62 seeds capsule^{-1} while 37 seeds capsule^{-1} were recorded in control plots. Similar increase was reported by Ahmed *et al.,* (1997) up to 88 kg P ha^{-1}. Interaction between I x P indicated by (Fig. 2) that seeds capsule^{-1} increased with increasing P levels in all irrigation interval. Linearly increase was recorded in seeds capsule^{-1} when supplied water with 9 days interval and treated with 90 kg P ha^{-1}.

Thousand seeds weight (g)

Mean value of irrigation interval revealed in table 1 that with increasing irrigation interval seed weight decrease and heavier (3.61 g) seed weight was obtained from 9 days irrigation interval which was (21 %) greater from 27 days irrigation interval. These results are in line with those of Jouyban *et al.,* (2011) who reported that significantly decreased in 1000 seed weight occur with increase irrigation interval from 6 to 18 days. Tillage system had significant effect on seed weight. Maximum (3.38 g) seed weight was produced in CT while minimum (3.26) seed weight was noted in ST but statistically had not significant difference with DT. These results are in line with the findings of Polat *et al.,* (2006) who reported that deep and shallow tillage reduced 1000 seed weight when compared with conventional tillage. Plot treated with 90 kg P ha^{-1} produced heavier (4 g) seed weight while minimum (2.51 g) seed weight was produced in control plots. These results are in line with those of Hafiz *et al.,* (2012) who reported the seed weight increased with increase phosphorus level up to 80 kg ha^{-1} as compared to control plots. Interaction between T x I x P revealed in (Fig. 3) that seed weight increased with increasing P levels in all irrigation interval and tillage system but linearly increased in seed weight was produced when given 9 days irrigation interval with CT and treated with 90 kg P ha^{-1}.

Seed oil content (%)

Analysis of data given in table 1 indicated that phosphorus levels had significantly affected oil content of sesame while irrigation interval, tillage system and all the interaction were found not significant effect on oil content. With increase of phosphorus level oil content increase significantly and therefore the highest level of phosphorus (90 kg ha^{-1}) produced maximum (58.21%) oil content while minimum (40.91%) oil content was recorded in control plots. Similar results were reported by Marschner (1986) who reported that increase in seed oil content (%) by adding phosphorus fertilization might be attributed to important role of phosphorus in metabolism of lipids.

Oil yield (kg ha^{-1})

Mean values in table 1 showed that oil yield was significantly reduced with increasing irrigation interval. Maximum (515 kg ha^{-1}) oil yield was produced from 9 days irrigation interval while minimum (365 kg ha^{-1}) oil yield was obtained from 27 day's irrigation interval. These results confirm the findings of Jouyban *et al.,* (2011) who reported that decreased oil yield with increasing irrigation interval from 6 to 18 days. Tillage system had significant effect on oil yield. Maximum (505 kg ha^{-1}) oil yield was recorded in CT while minimum (396 kg ha^{-1}) oil yield was noted in ST. These results are in line with those of Yol *et al.,* (2010) who reported the higher oil yield was obtained when conventional tillage system is applied as compared to deep and shallow tillage practices it might be due to tillage system which enhanced seed yield and indirectly increase oil yield. With increase of phosphorus level oil yield increased significantly and therefore the highest level of phosphorus (90 kg ha^{-1}) produced maximum (676 kg ha^{-1}) oil yield while minimum (161 kg ha^{-1}) oil yield was recorded in control plots. These results are in line with those of Ali and Sakr (2002) who reported that the positive effect of P application on oil yield ha^{-1} could be due to the increase in seed yield ha^{-1} and seed oil content (%). Interaction between T x I x P revealed in (Fig. 4) that oil yield increased significantly with increasing P levels in all irrigation interval and tillage system but maximum and linearly increased in oil yield was recorded when supplied water from 9 days irrigation interval with CT system and treated with 90 kg P ha^{-1}.

Seed yield (kg ha^{-1})

Supplied of water with 9 days irrigation interval produced maximum (957 kg ha^{-1}) seed yield while minimum (692 kg ha^{-1}) seed yield was obtained from 27 days irrigation interval. Similar results were reported by Jouyban *et al.,* (2011) who reported that 6 days irrigation interval increase (80.2%) seed yield when compared with 18 days irrigation interval. It was due to the decrease in inter-plant competition and the increase in auxiliary branch and capsules plant^{-1}. Tillage system had significant effect on seed yield. Maximum (949 kg ha^{-1}) seed yield was recorded in CT system while minimum (755 kg ha^{-1}) seed yield was recorded in ST system. These results are in line with those of Bulent *et al.,* (2012) who reported that higher seed yield was obtained when conventional tillage system is applied as compared to deep and shallow tillage practices. It might be due to high density of weeds biomass in deep tillage as compared to CT. With increase of phosphorus level seed yield increased significantly and therefore the highest level of phosphorus (90 kg ha^{-1}) produced maximum (1160 kg ha^{-1}) seed yield while minimum (392 kg ha^{-1}) seed yield was recorded in control plots. These results are in line with the findings Hafiz *et al.,* (2012) who reported that increase in seed yield due to phosphorus application was attributed to profound branching, better fruiting, increased number of seeds pod^{-1} and heavier seeds. Interaction between T x I x P indicated in (Fig. 5) that seed yield increased significantly with increasing P levels in all irrigation interval and tillage system but linearly increased in seed yield was recorded when supplied water from 9 days irrigation interval with CT system and treated with phosphorus at the rate of 90 kg ha^{-1}.

Biological yield (kg ha^{-1})

Water supplied with 9 days irrigation interval produced maximum (6642 kg ha^{-1}) biological yield while minimum (4625 kg ha^{-1}) biological yield was obtained from 27 days irrigation interval. Similar results were reported by Jouyban *et al.,* (2011) who reported that 6 days irrigation interval increase (44%) biological yield when compared with 18 days irrigation interval. It was due to the decrease in irrigation interval increased sesame vegetative growth, photosynthesis capacity and reduced inter-plant competition as a result biological yield eventually increased. Tillage system had significant effect on biological yield. Maximum (6054 kg ha^{-1}) biological yield was produced in CT system while minimum (5131 kg ha^{-1}) biological yield was produced in ST system. These results are in line with those of Bulent *et al.,* (2012) who reported that higher biological yield was obtained when conventional tillage system is applied as compared to deep and shallow tillage practices. With increase of phosphorus level biological yield increased significantly and therefore the highest level of phosphorus (90 kg ha^{-1}) produced maximum (6684 kg ha^{-1}) biological yield while minimum (3364 kg ha^{-1}) biological yield was recorded in control plots. These results are in line with the findings Hafiz *et al.,* (2012) who reported that P plays important role in enhancing translocation of metabolites which might be the reason for the increases observed in root density and proliferation which supply nutrients to plant as result biological yield increased. Interaction between T x I x P indicated in (Fig. 6) that biological yield increased significantly with increasing P level but beyond 60 kg P ha^{-1} further increased in biological yield was stop in all irrigation interval and tillage system but linearly increased in biological yield was recorded when supplied water from 9 days irrigation interval with CT system and treated with phosphorus at the rate of 60 kg ha^{-1}.

Table I. Number of capsules plant^{-1}, seeds capsule^{-1}, thousand seeds weight (g), oil content %, oil yield (kg ha^{-1}), seed yield (kg ha^{-1}) and biological yield (kg ha^{-1}) of sesame as affected by irrigation interval, tillage system and phosphorus levels

Treatment	Capsules plant^{-1}	Seeds capsule^{-1}	1000 seed weight (g)	Oil content (%)	Oil yield (kg ha^{-1})	Seed yield (Kg ha^{-1})	Biological yield (kg ha^{-1})
Irrigation interval (days)							
9	63a	59a	3.61a	50.59	515a	975a	6642a
18	54b	51b	3.31b	50.48	443b	837b	5448b
27	46c	42c	2.98c	50.40	365c	692c	4625c
LSD (0.05)	1.39	1.68	0.02	ns	4.84	8.71	24
Tillage systems							
Conventional(CT)	59a	53a	3.38a	50.84	505a	949a	6054a
Deep (DT)	53b	50b	3.27b	50.32	421b	801b	5530b
Shallow (ST)	52b	48c	3.26b	50.32	396c	755c	5131c
LSD (0.05)	1.39	1.68	0.02	ns	4.84	8.71	24
Phosphorus (kg ha^{-1})							
0	36d	37d	2.51d	40.91d	161d	392d	3364d
30	49c	47c	3.14c	48.43c	376c	777c	5669c
60	61b	55b	3.55b	54.43b	550b	1011b	6569b
90	71a	62a	4.00a	58.21a	676a	1160a	6684a
LSD (0.05)	1.03	0.40	0.03	0.19	4.81	9.65	16
Interaction							
I x T	ns	ns	ns	ns	ns	ns	ns
I x P	ns	*	ns	ns	ns	ns	ns
T x P	ns	ns	ns	ns	ns	ns	ns
I x T x P	*	ns	*	ns	*	*	*

Means in the same category followed by different letters are significantly different at

$P \leq 0.05$ levels. ns = non-significant

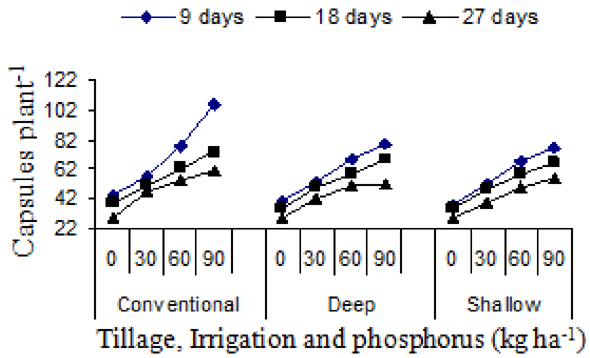

Fig. 1. Capsules plant^{-1} as affected by tillage, irrigation and phosphorus levels.

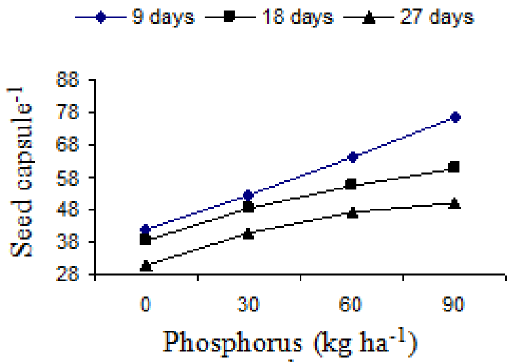

Fig. 2. Seed capsule^{-1} as effected by irrigation and phosphorus levels.

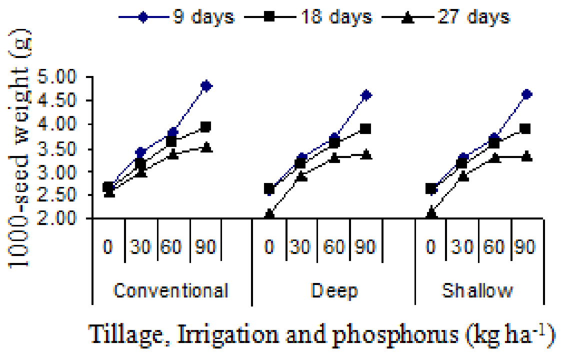

Fig. 3. 1000 seeds weight as affected by tillage, irrigation and phosphorus levels.

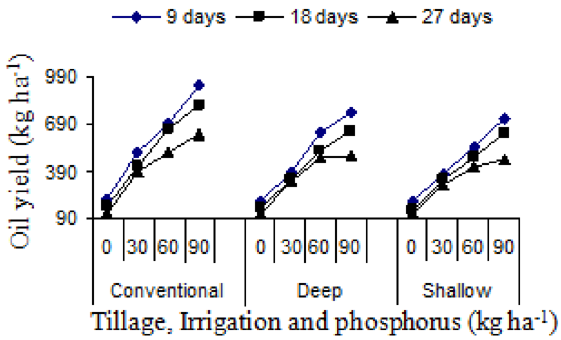

Fig. 4. Oil yield as affected by tillage, irrigation and phosphorus levels.

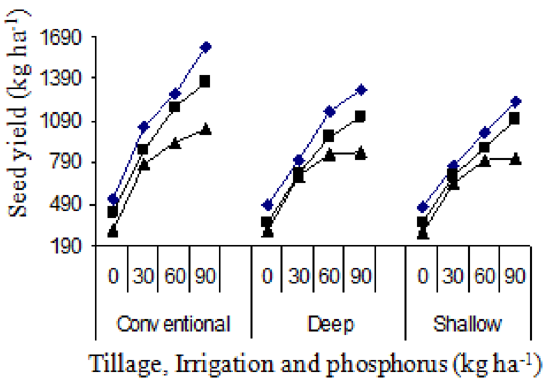

Fig. 5. Seed yield as affected by tillage, irrigation and phosphorus levels

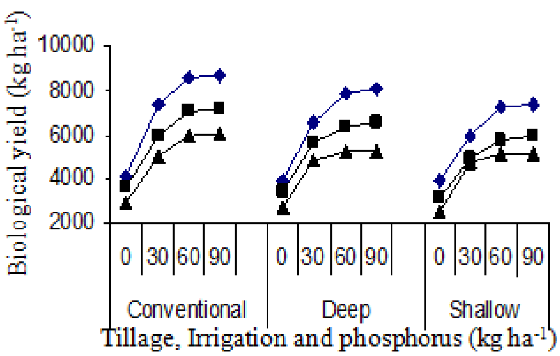

Fig. 6. Biological yield as affected by tillage, irrigation and phosphorus levels

CONCLUSION AND RECOMMENDATIONS

It was concluded from present research work that supplied water at 9 days interval with conventional tillage system and phosphorus at the rate of 90 kg ha^{-1} produced maximum 1000 grain weight oil yield and seed yield significantly and therefore, it is recommended to use irrigation interval of 9 days with conventional tillage system and application of phosphorus at the rate of 90 kg ha^{-1} under the conditions of the current study area.

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