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EFFECT OF WEED MANAGEMENT TECHNIQUES FOR BETTER GROWTH AND YIELD OF PEA (*Pisum sativum* L.)

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Though Pea is considered as one of the most important winter vegetable belonging to leguminoseae family is also very much prune to weed infestation. A study was conducted to observe the effect of various weed management techniques on weed density, plant growth, yield and yield contributing traits of pea. The experiments were laid out in Randomized Complete Block Design with six treatments replicated thrice. During 2011-12, the earliest germination (5.33 days) took place in plots where black plastic and transparent plastic were laid out as mulch, followed by control and hand weeding plots (6.33 days). The significantly tallest plants (65.57 cm), lowest weed density (13.43 m^2), minimum fresh weed biomass (35.72 g/ m^2), lowest dry weed biomass (12.54 g/ m^2), maximum number of pod per plant (21.03), the longest pods (7.54 cm), the highest weight of fresh pods per plant (44.17 g), number of gains per pod (8.02) and 100-grains weight (50.73 g) were recorded in hand weeded plots. Hand weeding recorded substantial increase in pod yield (8.63 t ha^{-1}) which was significantly the highest from all other treatments. In 2012-13, the significantly highest number of days taken to 50% flowering (65.33) was recorded in plots covered with white plastic. The lowest weed density (14.20 g/m^2), least fresh weed biomass (42.32 g/ m^2), the lowest dry weed biomass (15.19 g/ m^2), maximum number of pod per plant (14.76), the highest weight of fresh pods per plant (44.17 g), the longest pods (6.97 cm), maximum number of gains per pod (6.43) and the highest 100-grains weight (52.06 g) were recorded in hand weeded plots. Significantly the highest pod yield (7.66 t ha^{-1}) was also recorded in hand weeding. It was concluded that during both the years, hand weeding surpassed all other techniques in minimizing weeds density, weeds fresh and dry biomass enhancing all other growth and yield parameters followed by transparent plastic mulch, black plastic mulch, Dual Gold and Stomp.

Keywords: Pea, weed management, mulches, yield and growth, management techniques.

INTRODUCTION

Vegetables constitute an integral component of the cropping pattern as they fit well in most farming systems due to shorter maturity period. Vegetable crops are very important due to their higher yield potential, return, nutritional value and suitability for small land holding farmers. In Pakistan, more than 35 kinds of vegetables are grown in different eco-systems during summer, spring and winter seasons (Khokhar, 2014). Pea (*Pisum sativum* L.) belongs to Leguminoseae known as Fabaceae. Pea is regarded as an important legume crop of world (Hules, 1994) and cover 40% of total trading pulses (Oram and Agcaoili, 1994). Pea crops occupy third position among the major grain legumes in Pakistan (Aslam *et al*., 2000; Kazmi *et al*., 2002). In Pakistan, during 2013-14 the total area under pea cultivation was about 17406 hectares with the production of 114925 tones while KPK contributed an area of 1942 hectares with a production of 13418 tones (MNFSR, 2015).

There are many constraints which are responsible for its low yield such as promising varieties, lack of modern agricultural practices, water stress, unfavorable weather condition, but the biggest threat which is hindering its potential yield is the weed competition. If heavy weeds infestation are eradicated at their early stages (before competition), they would have a very little effect on final yield (Samedani, *et al*., 2015; Saqib *et al*., 2015). Weed management is a key issue in organic farming systems (Bond and Grundy, 2000). Peas are very poor in weed competition especially during their early stage. Weed management is an important agronomic issue in pea crops (Materne *et al*., 2002). The best time to control weeds in peas is before sowing (Harker *et al*., 2001). It has been estimated that weeds cause yield reductions as high as 20 to 40% in pea (Blackshaw and O'Donovan 1993; Ullah *et al*., 2008).

Normally farmers do not pay attention to yield losses due to weeds and they concentrate on other cultural practices than weed control (Ullah *et al*., 2008). Weed management aims at manipulating the competitive equilibrium in favor of the crop and to keep undesired weed growth at manageable levels rather than to totally eradicate weeds (Bond and Grundy, 2000). There are different weed management techniques, which include mechanical, cultural (hand weeding, hoeing, mulching, cover crops, crop rotation, intercropping) and the use of chemicals. Pre-emergence

herbicides are applied after planting the crop but before the crops or weeds emerge (Begeman, 1996). The pre-emergence herbicide gives the crop a good start, by eliminating early weed competition. However**, n**on-chemical weed control is being preferred as farmers seek more sustainable and environmental friendly farming methods. Muhammad *et al*. (2011) reported that 3 hand weeding effectively controlled weed density (96.22%) in chickpea. Singh and Wright (2002) found that higher concentration than recommended dose of different herbicides produce adverse effect on nodule, root and shoot growth of pea. Bakht *et al*. (2009) also reported that black polythene and newspaper mulch are effective and environment friendly in respect to sustainable weed control. Chemical control integrated with cultivation, rotation and hand weeding increase crop yield. The most popular plastic mulch is black, though clear, white on black, blue, green, red, yellow, brown and silver have also been tested (Ngouajio and Ernest, 2004; Lamont, 2005). Keeping in view, the disastrous effect of weeds the present study was designed to evaluate different weed management techniques (cultural and chemical) to encounter the destructive effect of weeds in pea production.

MATERIALS AND METHODS

Two year field trials were conducted to study the effect of different weed management techniques for the better growth and yield of Pea (*Pisum sativum* L.) at Research area of Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan during winter season 2011-12 and 2012-13. Climax variety was used for experimentation. The experiments were laid out in Randomized Complete Block Design (RCBD) with six treatments; each treatment was replicated thrice. The plot size was kept as 2.4×4.5 m^2. The treatments included Control, Stomp (Pedimethaline) 330 EC @ 2.5 L ha^{-1}, Dual Gold (S-metolachlor) 960EC @ 3.125 L ha^{-1}, three hand weeding, transparent plastic mulch and black plastic mulch. The land was well prepared and the recommended doses of pre-emergence herbicides Stomp and Dual Gold were applied before sowing of pea seeds in wetter condition in their respective plots, whereas both the plastic mulches (transparent and black) were also placed on their respective plots before sowing. Three hand weeding (20, 40 and 60 days after sowing) and control (weedy check) plots were also maintained in each replication. Both years the seeds were sown in last week of September, with row to row distance of 100 cm and plant to plant distance of 30 cm. The recommended dose of NPK (40:90:90 kg ha^{-1}) was applied in each plot. Full dose of P and K along with half dose of N were applied at the time of sowing whereas remaining half dose of N was applied one month after sowing. All the cultural practices except weeding and hoeing were carried out regularly during the research work. Data on days taken to seed germination, days taken to 50% flowering, plant height (cm), weed density (m^2), fresh weed biomass (g/m^2), dry weeds biomass (g/m^2), number of pods per plant, weight of fresh pods per plant (g), pod length (cm), number of seeds per pod, weight of 100-seeds (g) and seed yield (t ha^{-1}) were recorded and subjected to the statistical analysis by using the Analysis of Variance Technique (Steel *et al.,* 1997) while the method of Least Significant Difference (LSD) test at 5% probability was used to check the differences among various treatment means, if any.

RESULTS AND DISCUSSION

***Days taken to germination*:** The number of days taken to seed germination was significantly affected by different weed management strategies during both years, as reflected in Table 1. During 1st year the earliest germination (5.33 days) took place in plots where black and transparent plastic were laid out as mulch, followed by control and hand weeding plots which took 6.33 days each, all these four treatments were statistically at par. The seeds sown in plots applied with Stomp 330 EC and Dual Gold 960 EC showed significantly delayed germination (6.66 days) which was statistically similar to control and three hand weeding. In 2nd year, earliest germination took place in hand weeding and

Table 1. Effect of weed management strategies on germination, flowering and plant height of peas during 2011-12 and 2012-13.

Treatments	Germination (days)		50% flowering (days)		Plant height (cm)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Control	6.33 ab	5.66 b	62.64 b	63.13abc	57.84 c	51.42 e
Stomp 330 EC	6.66 a	6.66 a	64.90 a	64.60 ab	63.87 b	54.46 d
Dual Gold 960EC	6.66 a	6.90 a	64.22 ab	61.10 c	64.19 ab	58.56 c
Hand weeding	6.33 ab	5.66 b	62.96 b	62.62 bc	65.57 a	62.80 a
Transparent plastic	5.33 b	6.50 ab	65.33 a	64.22 ab	64.71 ab	59.77 bc
Black Plastic	5.33 b	6.70 a	65.07 a	65.46 a	65.02 ab	61.13 ab
$LSD_{0.05}$	1.08	0.88	1.67	2.76	1.40	2.04
SD	0.62	0.55	1.14	1.56	2.85	4.29

Means followed by similar letter(s) do not differ significantly at 5% level of significance

control plot taking 5.66 days each which in turn were statistically akin to transparent plastic mulch. While the transparent plastic and black plastic mulch took 6.50 and 6.70 days respectively and both these treatments were statistically alike. Application of Dual Gold delayed germination significantly by taking 6.90 days succeeded statistically similar by Stomp taking 6.66 days for germination. The data revealed that application of herbicides delayed germination while earlier germination was observed in control and transparent plastic covered plots. Contradictory to these results, Hassan and Waseem (2015) reported non significant results for days taken to germination while using different weed management technique.

***Days taken to 50% flowering*:** Days taken to 50% flowering were significantly influenced by adoption of different weed management measures (Table 1). In 1st year the significantly highest number of days taken to 50% flowering (65.33) was recorded in plots covered with transparent plastic mulch followed by black plastic mulch **with** 65.07 days to flowering which were statistically alike. Plants grown in control plot took the least days for 50% flowering (62.64) followed by three hand weeded plots (62.96 days). Among the chemically treated plots, Stomp and Dual Gold treated plots took 64.90 and 64.22 days to flowering, which were statistically similar to each other. During 2nd year of trail, black plastic covered plot flowered late (65.46 days) succeeded by statistically similar result obtained in transparent plastic and control plots with 64.22 and 63.13 days, respectively. The early flowering took place in hand weeding and control which was significantly akin to hand weeding and control with 62.62 and 63.13 days, respectively. Likewise, hand weeding and control were also statistically at par to transparent plastic mulch. Early flowering (61.10 days) was recorded in Dual Gold applied plot as compared to stomp treated plots with 64.60 days to 50% flowering.

The two years results showed that weed control measures delayed flowering as compared to weedy check. The delayed 50% flowering was recorded in plots where plastic mulches (black & transparent) were laid down, followed by plots sprayed with herbicides i.e Stomp and Dual Gold which might be due to delayed germination. Our results are analogous to finding of Bakht *et al*. (2009) who found that mulching delayed 50% flowering when pea performance was evaluated by different mulching materials. Ekinci and Dursun (2009) also reported earlier flowering in clear plastic as against black plastic while Khan *et al*. (2003) noticed delayed 50% flowering in herbicides treated plots as compared to control.

***Plant height (cm)*:** Plant height of pea was significantly ($P \leq 0.05$) affected by different weed control measures (Table 1). During 1st year, the significantly tallest plants (65.57 cm) were recorded in hand weeded plots very closely followed by black and the transparent plastic mulch**es** with 65.02 and 64.71 cm tall plants, respectively. However, all these treatments were statistically similar to each other. Whereas the least response (57.84 cm) for plant height was observed in control plot that differed significantly from all other treatments. Among the chemically treated plots Dual Gold produced taller plants (64.19) as compared to Stomp producing plant height of 63.87 cm and both these treatments were statistically alike. Same response for weed management practices was observed for plant height, during 2nd year. Hand weeded plants attained the maximum height (62.80 cm) closely followed by black plastic mulch covered plants with 61.13 cm height and both the treatments were significantly identical. The plants under transparent plastic mulch, possessed 59.77 cm height and were significantly similar to black plastic mulch. The shortest plants (51.42 cm) were found in control. The Dual Gold treated plants produced an average plant height of 58.56 cm while the Stomp treated plants attained plant height of 54.46 cm.

The data showed that hand weeded plots attained the tallest and healthy plants followed by the mulched plants (transparent and black) which might be due to timely eradication of weeds and creation of environment conductive to better plant growth. These results are in agreement with the previous inferences of (Bakht *et al*., 2009; Hutton and Handley, 2007) who found that mulching was effective in suppressing weeds and promoting plant growth. While (Khan *et al*., 2003; Sajid *et al*., 2012) also suggested herbicides application like Stomp and Dual gold for controlling weeds and promoting plant growth.

***Weeds density (m^2)*:** The experimental field was infested with different broad leaf as well as grassy weeds, however, the most abundant weeds were *Chenopodium album* L, *Anagallis arvensis* L, *Cyprus rotendus*, *C. Muale*, *Fumera indica* L, *Caronopus didymus* L, and *Vicia sativa* L. Statistical analysis of the data revealed that weed density m^2 was significantly reduced by different weed management practices during both years of study (Table 2). In 1st year, the maximum weed density (61.42 m^2) was recorded in the weedy check plot that differed significantly from other treatments, followed by both the mulches i.e black plastic and transparent plastic with 35.26 and 27.30 weeds m^2 respectively. The least weeds count (13.43 m^2) was reported in hand weeded plot. However, all the treatments varied statistically from each other. Amongst chemically treated plots highest weed density (50.20 m^2) was registered in Stomp as compared to Dual Gold (43.70 m^2) and both these treatments significantly differed to each other. During 2nd year, the highest weed density (66.20 m^2) was found in weedy check followed by black plastic mulch, transparent plastic mulch and hand weeding with 38.20, 29.42 and 14.20 m^2 weed density. Similarly, maximum weed density (53.00 m^2) was found in Stomp while the minimum weed density was recorded in Dual Gold as 46.50 m^2) and these both differed significantly to each other. All treatment varied

Table 2. Effect of weed management strategies on weeds density, fresh weed biomass and dry weed biomass in peas during 2011-12 and 2012-13.

Treatments	Weeds density (m^{-2})		Fresh weed biomass (g m^{-2})		Dry weed biomass (g m^{-2})	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Control	61.42 a	66.20 a	103.21 a	109.72 a	35.39 a	38.79 a
Stomp 330 EC	50.20 b	53.00 b	87.56 b	92.76 b	30.76 b	34.13 b
Dual Gold 960EC	43.70 c	46.50 c	76.62 c	83.12 c	26.93 c	30.65 c
Hand weeding	13.43 f	14.20 f	35.72 f	42.32 f	12.54 e	15.19 e
Transparent plastic	27.30 e	29.42 e	41.62 e	48.50 e	14.35 e	17.34 e
Black Plastic	35.26 d	38.20 d	60.50 d	66.00 d	20.86 d	23.38 d
$LSD_{0.05}$	4.48	1.87	3.14	2.29	2.38	1.84
SD	17.05	18.27	26.42	26.19	9.13	9.47

Means followed by similar letter(s) do not differ significantly at 5% level of significance

significantly in curtailing weeds counts. The least weed density in hand weeding might be due to elimination of weeds by manual weeding and absence of conditions conducive for weeds growth due to mulching. All the weed management practices significantly reduced the weed population compared to weedy check. The difference in weed population among treatments can be attributed to the fact that some weeds management techniques viz chemical, manual and mulches were more effective for weed control than the others. Between chemicals, Dual Gold was more efficient as compared to Stomp in controlling weeds. (Halniaz *et al*., 2014; Montaya *et al*., 2014; Sajid *et al*., 2012; Velykis and Satkus, 2010; Munakamwe, 2008; Kai, 2003) reported variety of weeds species in pea fields including weeds present in our field. Bakht *et al*., (2009) found that weeds density was remarkably reduced due to different mulches. The difference in weeds species might be due to variable soil and environmental conditions.

***Fresh Weed biomass (g/m^2)*:** Different weed management treatments manifested their significant effect on fresh weed biomass during both years of trail (Table 2). During 1st year, the maximum fresh weed biomass was recorded under weedy check (103.21 g/ m^2). The statistically minimum fresh weeds biomass (35.72 g/ m^2) was registered in hand weeded plot. However, all treatments varied significantly from each other. Different weeds controlling treatments resulted in 15.16 to 65.39% reduction in biomass. The maximum fresh weed biomass was found in chemically treated plots, where Stomp produced 87.56 g/m^2 fresh weed density as compared to Dual Gold (76.62 g/m^2) and both significantly differed to each other during 1st year. Similarly, in 2nd year, the significantly highest fresh weeds biomass (109.72 g/ m^2) was reported in control plot, followed by black plastic and transparent plastic mulch. The lowest biomass (83.12 g/ m^2) was observed in manual weeding. Among the chemically treated plots Stomp possessed highest fresh weed biomass (92.76 g/ m^2) as compared to Dual Gold (83.12 g/ m^2) and both differed significantly. All weed management techniques differed statistically from each other. Weeds management techniques reduced fresh weed biomass from 15.46 to 61.43% during 2nd year of trail. During both years, the maximum fresh weeds biomass in weedy check treatments might be due to increased weeds population owing to uncontrolled condition which favored vigorous weed growth leading to increased weed biomass. The maximum reduction in weeds biomass was noticed in hand weeding succeeded by transparent plastic mulch and black plastic mulch. Among chemicals, Dual Gold gave comparatively good control of weeds and hence reduced the weeds biomass). The data revealed that hand weeding and mulches provided satisfactory weed control and reduced weeds biomass significantly. Higher biomass in all treatments during 2nd year can be related to higher weeds density. Likewise, (Johnson and Holm 2010; Sajid *et al*., 2012; Singh, 2003; Muriakamwe, 2008) reported considerably reduced weed biomass due to application of herbicides while Bakht *et al*. (2009) recorded reduction in biomass with different mulching materials. However, Mathukia *et al*. (2015), Upadhyaya and Blackshaw (2007), Zimdahl (2007), Montanya *et al*. (2014) documented profound decrease in biomass in case of manual weeding.

***Dry weed biomass (g/m^2)*:** Different weed management practices exerted significant effect on dry weed biomass during two years study (Table 2). During 1st years, the statistically lowest dry weed biomass (12.54 g/m^2) was observed under hand weeding succeeded by transparent plastic mulch (14.35 g/m^2) and both treatments were statistically identical. These were followed by black plastic mulch with (20.86 g/ m^2) dry weed biomass . The maximum dry weed biomass (35.39 g/m^2) was recorded in weedy check that varied significantly from all weed controlling practices. The chemically treated plots of Stomp produced (30.76 g/m^2) dry weed biomass as compared toDual Gold with (26.93 g/m^2) and both behaved significantly differed to each other. The reduction in dry weed biomass s under hand weeding over weedy check was 64.57% in 1st year of trial. This might be attributed to the effective control of weeds

under this treatment which resulted in less number of weeds and ultimately lower weed biomass and reduced dry weed biomass Transparent plastic and black plastic mulch reduced 55.30 and 39.73% dry weed biomass as compared to control. The decrease in dry weed biomass was 20.98 % with Dual Gold and 12.01% with Stomp. In 2nd year of trail, minimum dry weed biomass (17.34 g/m^2) was recorded in hand weeding preceded by statistically similar to transparent plastic mulch (15.19 g/m^2) dry weed biomass The remaining treatments differed statistically from each other. The significantly highest dry weed biomass (38.79 g/m^2) was found in weedy check. Chemically treated plots of Stomp possessed dry weed biomass (34.13 g/m^2) while the Dual Gold produced (30.65 g/m^2) dry weed biomass and both these treatments were significantly differed. The decrease in dry weed biomass under hand weeding against weedy check was 60.84%. Transparent plastic and black plastic mulch reduced 59.45% and 41.06% dry weed biomass as compared to control, respectively. Application of Dual Gold and Stomp resulted in 23.91% and 13.08% reduction in dry weed biomass. The results showed that hand weeding excelled all other practices followed by transparent plastic, black plastic, Dual Gold and Stomp. These results are in agreement with the findings of (Munakamwe, 2008; Velykis and Satkus, 2010; Johnson and Holm, 2010; Montanya *et al*., 2014; Halniaz *et al*., 2014; Mathukia *et al*., 2015).

***Number of pods per plant*:** Significant variations existed among different weed management practices regarding number of pods per plant (Table 3). In 1st year the maximum number of pod per plant (21.03) were recorded in plots receiving hand weeding that differed significantly from all other treatments. It was followed by transparent plastic and black plastic mulch with 19.64 and 19.04 pods per plant, respectively and both the treatment were statistically similar to each other. The statistically lowest number of pods per plant (15.58) was recorded in weedy check. Among the chemically treated plots**,** Dual Gold produced 18.14 pods per plant as compared to Stomp (17.66and both were statistically alike. During 2nd year, the number pods per plant was considerably influenced by the different weed management strategies. Significantly the highest number of pods per plant (14.76) was observed in hand weeded plots closely followed by black plastic mulch and transparent plastic mulch with 14.03 and 13.69 pods per plant, respectively and all the three treatments were significantly identical. The plants from control plot produced significantly the minimum number of pods per plant (10.66), which was significantly akin to Stomp and Dual Gold treatment plants. Plants grown in Dual Gold treated plot also produced statistically similar number of pods (12.45) to Stomp treated plot as (11.70).

The results suggested that different weed control measures including manual, chemicals and mulching significantly increased the number of pods per plant as compared to weedy check (control).Hand weeding ranked first in enhancing the number of pods per plant followed by plastic mulches, Dual Gold and Stomp. Greater number of pods per plant might be due to favourable plant growth environment and healthy plants. As the competitive weeds were removed periodically, thus lowering their competition for nutrients, space, water and light. These results are in corroboration with the previous work (Khan *et al*., 2003; Sajid *et al*., 2012; Prakash *et al*., 2000; Jilani *et al*., 2007) who found that chemical control of weeds like application of Dual Gold and Stomp significantly improved plant growth and number of productive parts, i.e. pods per plant. Similarly, Banga *et al.*, (1998), Hutton and Handley (2007) and Bakht *et al*. (2009) reported that plastic mulching controlled weeds effectively and enhanced number of pods and yields of vegetables.

***Weight of fresh pods per plant (g)*:** The weight of fresh pods per plant was significantly increased by different weed management practices during both year (Table 3). In 1st year, the significantly highest weight of fresh pods per plant (44.17g) was recorded in hand weeded plot followed by transparent Plastic mulch (41.31g) . The transparent plastic

Table 3. Effect of weed management strategies on number of pod per plant, weight of fresh pod per plant, pod length of peas during 2011-12 and 2012-13.

Treatments	Number of pod per plant		Weight of fresh pod per plant (g)		Pod length (cm)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Control	15.58 e	10.66 c	33.79 d	33.80 d	5.40 e	5.47 d
Stomp 330 EC	17.66 d	11.70 c	37.71 c	36.96 cd	6.30 d	5.84 c
Dual Gold 960EC	18.14cd	12.45 bc	37.71 c	39.34 bc	6.59 cd	6.12 c
Hand weeding	21.03 a	14.76 a	44.17 a	44.21 a	7.54 a	6.97 a
Transparent plastic	19.64 b	13.69 ab	41.31 ab	40.56abc	7.11 ab	6.44 b
Black Plastic	19.04bc	14.03 ab	40.45 bc	41.843ab	6.96 bc	6.86 a
$LSD_{0.05}$	1.13	1.80	3.16	3.75	0.43	0.28
SD	1.86	1.55	3.59	3.68	0.75	0.59

Means followed by similar letter(s) do not differ significantly at 5% level of significance

mulched plants were significantly identical to black plastic mulch with 40.45 g fresh pod weight per plant. The lowest fresh pods weight per plant was observed in control plot that differed significantly from all other treatments. Statistically similar results were recorded in chemically treatment plots of Stomp and Dual Gold producing 37.71 g fresh pod weight per plot, each. Different weed management techniques significantly influenced the weight of pods per plant in 2nd year (Table 3). Among treatments, the pods collected from hand weeded plants possessed maximum weight (44.21 g), very closely followed by black plastic and transparent plastic mulch with 41.84 and 40.56 g, respectively. All these three treatment behaved statistically alike. The minimum fresh pods weight per plant (33.80 g) was recorded in control that was statistically akin to Stomp. The Stomp treated plots produced (36.96 g) fresh pod weight per plot as compared to Dual gold plot (39.34 g) and both these treatments were statistically akin to each other.

The data suggested that different weed management practices increased the weight of pods per plant as compared to control. Among treatments, hand weeding surpassed other treatments in enhancing weight of fresh pods per plant, followed by both the mulches (transparent and black), Stomp and Dual Gold sprays respectively. These results also showed that the treatment having more number of pod per plant has obvious more weight of fresh pod per plant (g) and vice versa. Several scientists have suggested conventional, chemical and mulching strategies for suppressing weeds and enhancing grain weight of crops (Khan *et al*., 2003; Sajid *et al*., 2012; Prakash *et al*., 2000; Jilani *et al*., 2007; Hutton and Handley, 2007). Similarly, Bakht *et al*. (2009) found that mulching like plastic as well as other materials controlled weeds effectively and enhanced number of pods and yields of vegetables. In all cases hand weeding excelled all strategies and resulted better growth of plants.

***Pod length (cm)*:** Pod length was significantly influenced by different weed management practices in pea during the both years (Table 3). Data indicated that during 1st year, maximum pod length (7.54 cm) was found in plants receiving hand weeding, followed by transparent plastic with 7.11 cm long pods. However, both treatments did not differ significantly. Transparent plastic mulch was also statistically similar to black plastic mulch producing pod length of 6.96 cm. The shortest pod length (5.40) cm was found in weedy check plants that varied significantly from all other treatments. Statistically similar pod length (6.59 and 6.30 cm) were recorded in Dual Gold and Stomp treated plots, respectively. In 2nd year, the significantly longest pods (6.97 cm) were found once again in hand weeded plot very closely succeeded by black plastic mulch (6.86 cm) and both these treatments were statistically at per. These were followed by transparent plastic mulch producing 6.44 cm long pods. Minimum pod length (5.47 cm) was found in control plot that differed statistically from all other weed control management practices. Statistically similar pod length (6.12 and 5.84 cm) was recorded in the plants grown in chemicals treated plots viz Dual Gold and Stomp, respectively.

The results indicated that weed management strategies including cultural and chemical practices significantly increased the pod length. Among treatments, hand weeding proved superior to other treatments while black and transparent plastic mulches were equally effective. The chemical methods were least efficient. Low weed competition and proper utilization of nutrients in weed managed plots has resulted in better performance of plants in vegetative growth and yield. Manual weeding, plastic mulching and chemicals were recommended for getting longer and heavier pods in pea (Khan *et al*., 2003; Sajid *et al*., 2012; Prakash *et al*., 2000; Bakht *et al*., 2009).

***Number of grains per pod*:** Significant variations existed among different weed management practices regarding number of grains per pod during two years study (Table 4). In 1st year, the highest number of grains per pod (8.02) was recorded in hand weeding that differed significantly from all other treatments except transparent plastic mulch producing 7.58 grains per pod. However, transparent plastic mulch was also significantly similar to black plastic mulch (7.38). The least number of grains per pod (5.70) was recorded in weedy

Table 4. Effect of weed management strategies on number of grains per pod, weight of 100-grains (g) and pod yield (t ha^{-1}) of peas during 2011-12 and 2012-13.

Treatment	Number of grain per pod		Weight of 100 grains (g)		Pod yield (t ha^{-1})	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Control	5.70 d	4.94 e	41.92 d	41.68 c	6.12 f	5.72 d
Stomp 330 EC	6.52 c	5.37 d	46.21 c	42.31 c	7.23 e	6.35 c
Dual Gold 960EC	7.06 bc	5.51 cd	46.72 c	46.98 b	7.68 d	6.53 c
Hand weeding	8.02 a	6.43 a	50.73 a	52.06 a	8.63 a	7.66 a
Transparent plastic	7.58 ab	5.78 bc	48.80 b	49.10 ab	8.38 b	7.35 b
Black Plastic	7.38 b	5.99 b	47.79 bc	50.59 ab	8.18 c	7.30 b
$LSD_{0.05}$	0.63	0.33	1.93	3.81	0.17	0.27
SD	0.83	0.52	2.98	4.32	0.92	0.74

Means followed by similar letter(s) do not differ significantly at 5% level of significance

check that differed significantly from all other treatments. Amongst, chemically treated plots, statistically similar results were recorded for Dual Gold and stomp with 7.06 and 6.52 grains per pod, respectively. During 2nd year, the significantly maximum number of grains per pod (6.43) was once again noticed in plants grown in hand weeded plots. It was followed by black plastic and transparent plastic mulch with 5.99 and 5.78 grains per pods, respectively and both these treatments with statistically at par. Significantly the least number of grains per pod (4.94) was found in control plants. Statistically alike results were reported in Dual Gold and Stomp with 5.51 and 5.37 grains per pod.

The results once again indicated that different weed control measures increased the number of grains per pod as compared to weedy check (control). Among weed management techniques, hand weeding produced the maximum number of grains per pod followed by both the mulches (transparent and black plastic), Dual Gold and Stomp respectively. Due to low weed competition for nutrients and light, the weed control treatment effectively utilized them to gain maximum number of grain per pod. Similarly, results were quoted by James *et al*. (2006) and Hasan and Waseem (2015) who also reported maximum pod grain per pod, when hand weeding technique was used to check weed.

***Weight of 100-grains (g)*:** Significant differences in weight of 100-grains existed among the treatments during two years study (Table 4). In 1st year, the highest 100-grains weight (50.73 g) was recorded in hand weeding that varied significantly from all other treatments. It was followed by statistically similar results recorded in transparent plastic and black plastic mulch with 48.80 and 47.79 g weight of 100 grains respectively. The significantly lowest 100-grains weight (41.92 g) was noted in control plots. The Dual Gold treated plot obtained (46.72 g) while the stomp treated plot produced 46.21 g weight of 100- grains, respectively and both these treatments were statistically similar to each other. During 2nd year, the highest 100-grains weight (52.06 g) was once again observed in hand weeding, succeeded by black plastic and transparent plastic mulch with 50.59 and 49.10 g respectively and all the three treatments were significantly similar. The lowest 100-grains weight (41.68 g) was found in control plot that was significantly identical to stomp (42.31 g). Whereas, Dual Gold plot produced 46.98 g weight of 100 grains.

The results suggested that different weed management practices increased the weight of 100-grains of pea as compared to control. Among treatments, hand weeding surpassed other treatments in enhancing the weight of 100-grains, followed by mulches (black and transparent plastic), Dual Gold and Stomp. This might be due to the fact that plants allocated maximum resources of nutrients to the crop due to no weed competition in hand weeding. Sajid *et al*. (2012), Bakht *et al*. (2009) and James *et al*. (2006) also recorded greater 100-seed weight by applying various weed management practices in pea.

***Pod yield (t ha^{-1})*:** The data regarding pod yield (t ha^{-1}) of pea as affected by different weed control measures are presented in Table 4. The results indicated that pod yield (t ha^{-1}) differed significantly among treatments during both years. In 1st year, the highest pod yield (8.63 t ha^{-1}) was recorded in hand weeding. It was succeeded by transparent plastic, black plastic mulch producing 8.38 and 8.18 t ha^{-1} pods, respectively. All treatments differed statistically from each other. Amongst chemically treated plot, Dual Gold produced 7.68 t ha^{-1} as compared to 7.23 t ha^{-1} pod yield produced by Stomp which behaved significantly different to each other. Considerable differences were observed in pod yield (t ha^{-1}) among treatments during 2nd year of study. Hand weeded plot once again produced significantly the highest yield (7.66 t ha^{-1}) that differed statistically from all other treatments. It was followed by transparent plastic mulch and black plastic mulch fetching 7.35 and 7.30 t ha^{-1} pods, respectively and both treatments were statistically similar. The significantly lowest pod yield (5.72 t ha^{-1}) was observed in weedy check. The statistically similar pod yield (6.53 and 6.35) t ha^{-1} were recorded in Dual Gold and Stomp applied plots. The results revealed that different weed management techniques considerably enhanced the pea pod yield. Better production and yields by adopting chemical control measures of weeds is previously confirmed (Banga *et al*., 1998; Prakash *et al*., 2000; Khan *et al*., 2003; James *et al*., 2006; Sajid *et al*., 2012). Moreover, greater yields of crops with plastic mulching is also reported (Ngouajo *et al*., 2008; Melekk and Dursan, 2009; Bakht *et al*., 2009; Hassan and Waseem, 2015). These results are also in conformity with that of Townley and Wright (1994) who stated that good weed control is critical for attaining high pea crop yield. In all cases, the highest pod yields were recorded in hand weeded plots, although those might not be economically feasible.

***Conclusion*:** Authors may arrive at conclusion that different weed management techniques including cultural practices (i.e, hand weeding, white plastic mulch, black plastic) and chemical treatments (i.e Dual Gold and Stomp) have significantly influenced plant growth, yield and yield contributing traits of pea during years 2011-12 and 2012-13. Findings revealed that hand weeding was found instrumental among tested treatments in enhancing the yield of peas substantially.

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