Research Article

Forages Growth and Yield Response in Crops Mixture and Pure Stands under Conventional Vs Conservation Tillage in Rainfed

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Abstract | Forage based double cropping system is essential for the sustainable development of Pothowar region. Field experiment was conducted to evaluate forage growth and yield of oats (*Avena sativa*) and vetch (*Vicia sativa*) grown in mixture stands under conservation and conventional tillage systems. The highest number of tillers plant-1 (11) for Oats was recorded in oats-vetch mixture under conventional tillage (CT) while comparing minimum tillage (MT) to zero tillage (ZT) 43 percent higher yield of oats was obtained under MT. The impact of cereal legume mixture on forage yield was optimistic. In economic analysis MT depicted the highest net benefit per hectare over both other tillage systems that are conventional and zero-tillage with values of 632.87 $ ha^{-1} and Rs.152.22 $ ha^{-1}, respectively for oats and vetch. Forage growth and yield were improved for oats in oats-vetch mixture under minimum tillage while vetch performed well in crops mixture stands. Forage yield improved by oats-vetch mixture improved agronomic practices. Maximum forage economic cost benefits in case of both oats and vetch were achieved in case of minimum tillage.

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Keywords | Zero tillage, Forages, Oats, Vech, Net benefit

Introduction

In rain fed regions main problem is the provision of sufficient nutritional forage for live stocks rearing. Against the estimated requirement of 358.11 million tons, only 165.76 million tons of green forage is available for livestock in Pakistan, which present 53.71% forage deficiency of forage (Yaseen, 2018). At the present time availability of natural vegetation is generally unable to meet the feed and nutritional requirements of farm animals. Researchers are trying to depict importance of forages quality and quantity in on farm agriculture. The disparity among forages for number of leaves might be attributed to their morphological characters (Moncao et al., 2016) and significant variation is due to different genetic characteristics and environment (Mekhasha et al., 2008). The more the number of leaves, the more will be the green and dry forage yield (Bakhsh et al., 2007). Some related to this other agronomic parameter are also directly correlated with yield. Such as plant height is one of the main components of plant growth and has a vital role towards final yield especially in forages where the main emphasis specified on the plant biomass. The variation in plant height could be the result of difference in genetic composition and

environmental circumstances (Nawaz et al., 2004; Lodhi et al., 2009). Number of tillers/branches per plant is also an essential growth component that contributes towards forage yield (Mamatha et al., 2006). Ahmadi and Bahrani (2009) found number of branches in forage crops because of availability of adequate soil moisture and nutrients. The forages requirements can meet by many ways like cereal-legume mixture, supply of farm by products and use of concentrates (Mpairwe et al., 2003). Combination of cereal-legume mixture is the most cost-effective method while others are expensive. Cereal-legume mixture is a legitimate solution to meet the shortage of forage (Mpairwe et al., 2003) and to obtain cost effective production (Ghosh, 2004). It has been reported that vetch with cereals facilitates forage growth whereas cereals provide structural support and better light interpretation (Corleto et al., 2005).

Intensive tillage operations have formed some problems such as high cost of production, more fuel and time consumption, formation of plough pane and damage to soil structure. Technical provisions in agriculture have directed scientists to keep check on existing practices like tillage systems towards cost benefit production. High plant growth, agronomic productivity and improved soil conditions be achieved by minimum tillage and no-tillage (Papini et al., 2007). Minimum tillage proved to be energy saving, avoiding risk of soil erosion and minimizing cost of production (Hassan et al., 2016) improving infiltration and reducing evaporation to conserve soil water (Moraes et al., 2013; Qingjie et al., 2014). Researchers accepted as true that no-tillage is more beneficial than conventional. No-tillage resulted in greater canola chaff yield (Malhi et al., 2006), improved emergence in wheat (Wiatrak et al., 2006), improved pea yield and nitrogen uptake (Soon and Arshad, 2005) when compared to conventional tillage.

Keeping in view above two aspects, insufficient and limited investigation on cereal-legume mixture with respect to forage growth and yield has carried out in subtropical dry region of Pakistan. Furthermore, none of the study reveals about the companion crop effect on cereal forage yield with respect to tillage system. So, this study was designed to examine agronomic parameters and forage yield of oats (*Avena sativa*) and vetch (*Vicia sativa*) grown in pure stands and cereal-legume mixture under conservation (zero-tillage and minimum tillage) and conventional tillage systems.

Materials and Methods

Experimental site

Field experiment was conducted at Pir Mehr Ali Shah Arid Agriculture University (PMAS-AAUR) Research Farm, Koont (73 ° 05´ E longitude and 33 ° 38´ N latitude) located in a subtropical rainfed region during winter 2013 and 2014. It is classified as Rawal series, Udic Haplustalf, alfisols (GoP, 1974) with loam texture. The physico-chemical properties of soil such as electrical conductivity (EC), organic matter content, available phosphorous and potassium were 0.96 dS m^{-1}, 0.64 g $100g^{-1}$, 7.64 mg kg^{-1} and 113.8 mg kg^{-1}, respectively. The rainfall incidence recorded during both years of experimentation showed bi-model behavior with two maxima, one in late summer (August and September) and second during the winter-spring (February and March). Long term rainfall distribution of the site during winter and summer was 30% and 70%, respectively. Figure 1 reflects the total monthly rainfall and mean monthly temperature reported during crop growth at experimental site.

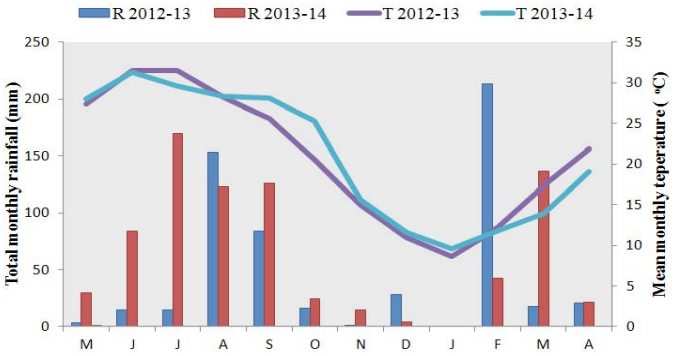

Figure 1: *Total monthly rainfall (mm) and mean monthly temperature (°C) during study period.*

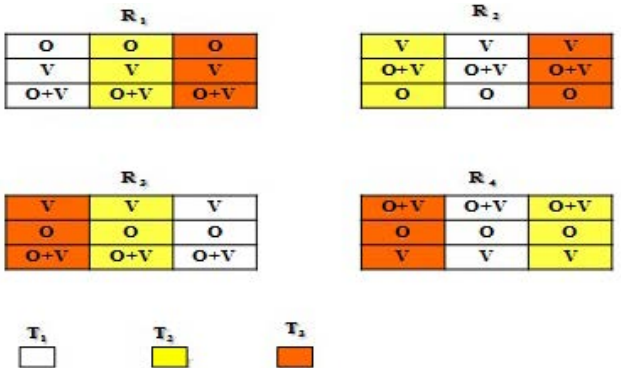

Figure 2: *The experiment lay out; Where, O= oats pure stand; O+V= oats-vetch mixture; V= vetch pure stand; R_1= first replication; R_2= second replication; R_3= third replication; R_4= fourth replication; T_1= zero tillage; T_2= minimum tillage (one tillage with moldboard plough and four ploughings with cultivator) and T_3= conventional tillage (one tillage with moldboard plough and six ploughings with cultivator).*

Field trial

Field trail was conducted in strip-plot design with four replications. Plot size was 72 m^2 and 20 plots were maintained per replication. The layout of experiment is presented in Figure 2. Winter wheat was grown previous and harvested in the last week of April, 2012 and straw of wheat was removed after harvest. Oats (*Avena sativa* L., cv. PD_2 LV_{65}) and vetch (*Vicia sativa* L., cv. Languedock) were sown. The proportion of cereal and legumes in mixture was 70% oats and 30% vetch i.e. 2.3:1 ratio. In mixture treatments, both component crops analyzed separately for yield and agronomic parameters. Cereal-legume treatments comprised of: O_1) oats pure stand, O_2) oats in oats-vetch mixture, vetch pure stand and vetch in oats-vetch mixture. Tillage treatments were zero-tillage (no-till + Glyphosate herbicide), minimum tillage (one tillage was done with moldboard plough and four ploughings with cultivator) and conventional tillage (one tillage was done with moldboard plough and six ploughings with cultivator). Both crops were sown in the last week of October for both the year. The plots of zero-tillage were planted with no-tillage drill (Figure 5e) while rest of the plots was planted with conventional wheat seed drill (Figure 5f). The experiment was carried out in the same field during 2013-2014. The seed @ for cereal and vetch were 80 kg ha^{-1} and 30 kg ha^{-1}, respectively and were treated with Topsin-M @ 2g kg^{-1} before sowing to control fungal diseases. The row to row space was 22.5 cm and a buffer zone of 1m between plots was maintained during sowing. Urea (46% N) and diammonium phosphate (DAP, 18% N and 46% P_2O_5) were used to supply N and P, respectively. Rates of fertilizer of nitrogen and phosphorous were 120-80 kg NP ha^{-1} for cereal crop and 0-40 kg NP ha^{-1} for legume crop, respectively, before sowing of crops. Forage crops were harvested in February (110 DAS, days after sowing) at booting stage of cereal and flowering stage of legume during both growing seasons.

Forage yield and agronomic parameters

Two samples from one meter square area were taken randomly from each plot and their fresh weight was converted into tons ha^{-1}. For number of leaves $plant^{-1}$ and number of tillers (cereal) $plant^{-1}$ or number of branches (legume) $plant^{-1}$, five randomly selected plants from each plot were counted at the time of harvest and then average was calculated. Plant height (cm) was measured from same five plants with the help of meter rod and their average was taken in to account for statistical analysis.

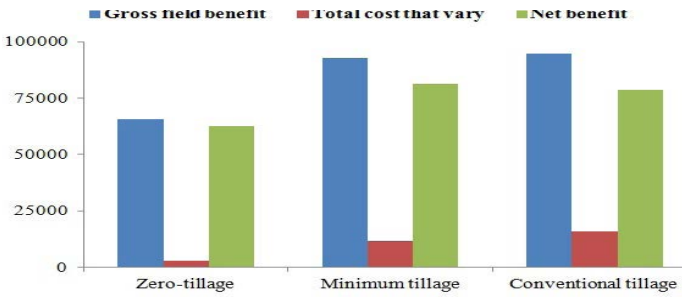

Figure 3: *The economic parameter used in dominance analyses for oats.*

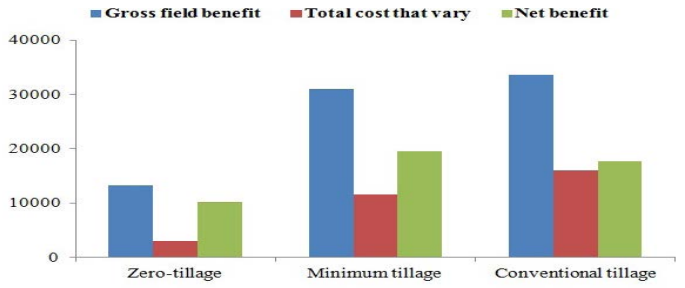

Figure 4: *The economic parameters used in dominance analyses for vetch.*

Figure 5: *a) cultivation with mould board plough. B) zero-till plots. c) Cultivation with cultivator. d) Early stage of crops. e) Sowing with zero-till drill. f) Sowing with wheat seed drill. g) Experimental field. h) Vetch at flowering stage. i) oat at booting stage. j) Oat-vetch mixture.*

Economic analysis

The experimental data were analyzed for dominance analysis according to methodology described in CIMMYT (1988).

Statistical analysis

Combined analysis of two years was made by using Statisix.8.1, software (Tallahassee, Florida, USA) for analysis of variance (ANOVA) in strip-plot design. Means were compared at five percent significance level by least significant difference (LSD) test.

Results and Discussion

Number of leaves plant^{-1} in oats and vetch

When we consider the variation on number of leaves plant^{-1} in oats and vetch due to interaction of tillage system and crop, the highest number of leaves plant^{-1} of 32 under conventional tillage in oats-vetch mixture while the lowest 23 was recorded under zero-tillage in oats pure stand while the highest number of leaves plant^{-1} (946) was recorded in conventional tillage in vetch pure stand and the lowest 209 were found in case of zero-tillage for vetch in oats-vetch mixture (Table 1). The 8% increase in number of leaves plant^{-1} occurred when oats were grown in oats-vetch mixture (70:30 ratio) which was probably due to the result of nitrogen fixation by vetch in the soil with enhanced number of tillers plant^{-1}. Vetch showed comparatively inverse response to cereals for this parameter as it produced greater number of leaves plant^{-1} in pure stand due to more space available for its potential spread and also due to more number of branches as vetch availed more geo-environmental resources for growth in monoculture and expressed maximum potential and hence produced comparatively more number of branches and leaves. Dwivedi et al. (2016) also reported that more green forge yield is the result of more number of leaves plant^{-1}, more plant height and leaf length.

Table 1: *Mean number of leaves plant $^{-1}$ of cereal–legume mixture under different tillage system.*

Crop	Tillage systems			Mean
	Zero tillage	Minimum tillage	Conventional tillage	
Oats pure stand	23e	28c	30b	27b
Oats in oats-vetch mixture	25d	30b	32a	29a
Vetch pure stand	917c	939b	946a	934a
Vetch in oats-vetch mixture	209f	227f	234d	223b
Mean (Oats)	24c	29b	31a	
(Vetch)	563c	583b	590a	

Any two means not sharing a letter in common differ significantly at 5% level of probability.

The duration of the vegetative phase is prolonged by increased number of leaves and photoperiod responsiveness. Number of leaves plant^{-1} is an important agronomic parameter which has direct relation to photosynthetic activity in plants. The more the number of leaves, the more will be the green and dry forage yield (Bakhsh et al., 2007). The disparity among forages for number of leaves might be attributed to their morphological characters (Bhatti et al., 1992). Similarly, Mekhasha et al. (2008) stated that number of leaves significantly varied due to different genetic characteristics. The possible reason of enhanced number of leaves plant^{-1} was due to more number of tillers plant^{-1} as a result of sufficient provision of nutrients including nitrogen by legume to the cereals. Ahmad et al. (2011) concluded that nitrogen contribute significantly to increase number of leaves plant^{-1}.

Plant height in oats and vetch (cm)

Tillage × crop interaction showed statistically significant differences for plant height of oats and vetch. Oats pure stand in conventional tillage produced the longest plants of 140 cm while oats in oats-vetch mixture has given the shortest plants of 129 cm. The cereal-legume mixture and tillage systems showed statistically significant effect on plant height. Vetch in oats-vetch mixture produced the longest plants of 73 cm in conventional tillage while vetch pure stand resulted in the shortest stature plants of 53 cm (Table 2). Vetch in oats-vetch mixture produced 14% longer plants than vetch in pure stand.

Table 2: *Mean plant height (cm) of cereal–legume mixture under different tillage system.*

Crop	Tillage systems			Mean
	Zero tillage	Minimum tillage	Conventional tillage	
Oats pure stand	129f	135d	136c	133.26b
Oats in oats-vetch mixture	132e	138b	140a	136.61a
Vetch pure stand	53e	61d	65c	59.71b
Vetch in oats-vetch mixture	61d	69b	73a	67.59a
Mean (Oats)	130c	136b	138a	
(Vetch)	57c	65b	69a	

Any two means not sharing a letter in common differ significantly at 5% level of probability.

Plant height is an important and main character for plant growth and yield in cereal forages and it plays

a key role towards forages yield where the main emphasis is given on the plant biomass. The higher plant height was recorded for cereal in cereal-legume mixture than cereal pure stand which was probably due to more favorable conditions for legumes to fix nitrogen from the environment and to provide it to companion cereal crop. The variation in plant height could be the result of difference in genetic makeup and environmental conditions (Nawaz et al., 2004; Lodhi et al., 2009). More biomass and enlargement of tissues were noticed was probably due to availability of nitrogen contributed by legume (vetch) to the cereal. Mekhasha et al. (2008) found improved plant height due to soil nitrogen. Sachanski and Kirilov (1988) reported that the sowing of oats in a mixture minimized the lodging of vetch, thus increased the nutritive value of the forage. Our findings confirmed the results of Ansar et al. (2010), who reported highesr plant height of oats than cereal-legume mixture. Our results differed from Dwivedi et al. (2016), who reported higher plants in pure stand instead of cereal-legume mixture.

The reason for cereal-legume impact on plant height was due to cereal contribution to provide physical climbing support to vetch as a result the vetch gained more height while in pure stand no such support was available for legume (vetch). Vetch in mixtures improved the plant height also due to its contribution for nitrogen by atmospheric nitrogen fixation (Thompson et al., 1992). Plant height is result of genetic makeup, adequate moisture and optimum temperature which support vegetative growth of crop. Our results are in line with the findings of Nagabhushanam and Raghavaiah (2005), who reported taller plants in castor bean.

Number of tillers/branches in oats and vetch

The tillage and crop showed significant differences for number of tillers in oats and number of branches in vetch. The highest number of tillers plant^{-1} (11) was recorded in conventional tillage in oats-vetch mixture while minimum number of tillers plant^{-1} (5) was found for oats pure stand in case of zero-tillage. The highest number of branches plant^{-1} (14) was recorded in conventional tillage in vetch pure stand while the lowest number of branches plant^{-1} (5) was found for vetch in oats-vetch mixture under zero-tillage practice (Table 3).

Number of tillers/branches plant^{-1} is an essential growth component which contributes towards forage yield (Mamatha et al., 2006). Large number of tillers plant^{-1} bear greater number of leaves which clearly indicated more photosynthetic activity in them. High biomass resulted from more photosynthates which contributed towards high final forage yield. Number of tillers plant^{-1} was the result of number of increased tillage operation. Oats in oats-vetch mixture produced greater numbers of tillers than it's pure stand. The reason for this was the legume contribution towards soil fertility and hence more tillers persist initially. Similar findings were reported by Canan and Orak (2007), who reported higher number of tillers/ branches plant^{-1} for oats and vetch in oats-vetch mixture than their respective pure stands. Similarly, Barsila (2018) reported the same findings for barley in barley-vetch mixture. Higher number of branches plant^{-1} produced by vetch did not show major effect on forage yield due to vetch's smaller and thin branches with lower leaf area as compared to oats. The highest number of branches in vetch pure stand was due to its spreading growth nature that reduces evaporation and hence helped to retain and conserve more moisture in soil. The reason for producing the highest number of tillers plant^{-1} may be due to its genetic makeup and well adaptability to environmental factors of experimental site especially rainfall. Such results have been recognized by Quemada et al. (2016) observations number of branches due to adequate soil moisture. These results of vetch are contradicting with findings of Canan and Orak (2007), who reported higher number of branches or tillers in cereal-vetch mixture, while that case is true for cereal in present study.

Table 3: *Mean number of tillers/ branches of cereal-legume mixture under different tillage system.*

Crop	Tillage systems			Mean
	Zero tillage	Minimum tillage	Conventional tillage	
Oats pure stand	57f	8d	10b	8^{NS}
Oats in oats-vetch mixture	6e	9c	11a	8
Vetch pure stand	9d	12b	14a	12a
Vetch in oats-vetch mixture	5f	8e	10c	3b
Mean (Oats)	5c	8b	10a	
(Vetch)	7c	10b	12a	

Any two means not sharing a letter in common differ significantly at 5% level of probability; NS= Non-significant.

Forage yield of oats and vetch

The results of this study revealed that conventional tillage (farmer practice) enhanced the forage yield compared to both, reduced and zero-tillage with values of 52.63, 51.50 and 35.91 t ha^{-1}, respectively for oats; 23.50, 21.88 and 9.38 t ha^{-1}, respectively for vetch (Table 4) but when we compare them in economic analysis minimum tillage showed the highest net benefit ha^{-1} over conventional and zero-tillage for both the crops with values of Rs. 81175, 78791 and 62475 ha^{-1}, respectively for oats (Figure 3); Rs.19525, 17609 and 10203 ha^{-1}, respectively for vetch (Figure 4).

Table 4: *Mean green forage yield (t ha^{-1}) of cereal-legume mixture under tillage system.*

Crop	Tillage systems			Mean
	Zero tillage	Minimum tillage	Conventional tillage	
Oats pure stand	36.66f	48.50d	49.50c	44.89b
Oats in oats-vetch mixture	38.16e	54.50b	55.75a	49.47a
Vetch pure stand	16.00c	35.50b	37.00a	29.50a
Vetch in oats-vetch mixture	2.75f	8.25e	10.00d	7.00b
Mean (Oats)	35.91c	51.50b	52.63a	
(Vetch)	9.38c	21.88b	23.50a	

Any two means not sharing a letter in common differ significantly at 5% level of probability.

When we consider the variation in yield due to tillage systems and cereal-legume mixture, higher yield of 55.75 t ha^{-1} was recorded under conventional tillage in oats-vetch mixture than in case of zero-tillage in oats pure stand with yield of 33.66 t ha^{-1}. The interaction of tillage systems and cereal-legume mixture for vetch showed that the highest yield of 37.00 t ha^{-1} was recorded under conventional tillage in pure vetch while the lowest yield of 2.75 t ha^{-1} was for vetch noted in oats-vetch mixture (Table 4) under zero-tillage.

This study compared the effect of tillage systems and cereal-legume mixture on forage yield and agronomic parameters of oats and vetch crops. Forage yield depends on the inherited material of a genotype and the environment in which crops were grown. The tillage system with cereal-legume interaction showed significant effect on green forage yield of oats and vetch. Although the highest yield of oats and vetch was recorded in conventional tillage (farmers practice) but for economic analysis such as dominance analysis the highest net benefit gets priority over yield and the highest net benefit was received in case of minimum tillage (conservation tillage). Researchers believe that no-tillage is more beneficial than either deep, conventional or minimum tillage. No-tillage resulted in greater canola chaff yield (Malhi et al., 2006), improved emergence in wheat (Wiatrak et al., 2006), improved pea yield and nitrogen uptake (Soon and Arshad, 2005) when compared to conventional tillage. The reason for the lowest yield in case of zero-tillage in this study was often failure of zero-tillage drill to plant seed down in soil. The same was observed by Zhao et al. (2012). The second reason for lowest yield obtained in zero-tillage in this experimental site zero-tillage was experienced for the first time and also due to all allopathic effect of previous wheat straw in the field. The "loam" nature of soil of site mostly show significant higher yield in the long term i.e., mostly after five years. The research is continued on this site and we will hope that zero-till plots will show the desired results in the long run.

The higher forage yield of oats in oats-vetch mixture might be for nitrogen contribution by vetch through atmospheric nitrogen fixation. Pure vetch stand showed yield advantage over vetch yield in oats-vetch mixture. The lowest yield of vetch in case of cereal-legume mixture was probably due to shading effect of oats. Furthermore, the low availability of light resulted in leaves chlorosis and as a result their early necrosis in vetch. Cereals are more competitive than vetch for natural resources especially light and space which negatively affected vetch yield. This was also due to senescence of lower leaves and branches of vetch.

Conclusions and Recommendations

Forage yield acquired by improved agronomic parameters from oats in oats-vetch mixture than oats pure stand while high forage yield and improved agronomic parameters for vetch were obtained in vetch pure stand. Higher forage economic benefits in case of both oats and vetch were noticed in case of minimum tillage (single tillage with moldboard plough and four ploughings with a cultivator).

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Author's Contribution

Dr. Muhmmad Rasheed coordinated experiment till submission of paper, overall management, Zafar Ullah conducted Experiment, Muhammad Ansar, helped in field experimentation, Asma Hassan assistant in pre-pration of first draft, Shahzada Sohail Ijaz helped in soil analyses, Muhammad Hussain Shah statistical inputs, Muhammad Arshadullah technical formate to submission in PJAR.

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