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Integrated use of phosphorus and organic matter improve fodder yield of Moth bean (*Vigna aconitifolia* (Jacq.) under irrigated and dryland conditions of Pakistan

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ABSTRACT

A field experiment was conducted to investigate the impact of phosphorus (30, 45 and 60 kg P ha-1) and organic matter (canola straw, berseem straw and farmyard manure) on growth and fodder yield of moth bean (*Vigna aconitifolia* Jacq.) under irrigated and dryland conditions. The experiment was conducted under two field conditions viz. (i) with irrigation and (ii) without irrigation (dryland). The experiment under each field condition was laid out in a randomized complete block design having three replications. The results revealed that P and organic matter treated plots (rest) under both irrigated and dryland conditions had better growth and produced higher fresh and dry fodder yields over control (no P and no organic matter applied). Moth bean planted under irrigated condition (no moisture stress) had improved growth, and produced higher fresh and dry fodder yields over dryland condition. Increasing the rate of P increased growth, fresh and dry fodder yields (60 kg P ha^{-1} > 45 kg P ha^{-1} > 30 kg P ha^{-1}). Increase in growth, fresh and dry yields was obtained with the application of farmyard manure over plant residues incorporation. We concluded from this study that application of P at the highest rate of 60 kg P ha^{-1} along with farmyard manure (5 t ha^{-1}) as source of OM improve growth and fodder yield of moth bean under irrigated and dryland conditions under semiarid climates.

Keywords: Dryland, canola straw; berseem straw; farmyard manure; moth bean, semiarid climate

INTRODUCTION

Fodder production is the major limiting factor for livestock production in Pakistan. Improvement in livestock production depends on the proper quantity and quality of feed (Amanullah and Hatam, 2000). The importance of forage crops in agriculture can be gauged from the fact that regular supply of adequate and nutritious forage is required for better livestock production to meet the ever increasing demand of population for meat, milk, hides and wool (Chaudhry *et al.*, 1985). In Pakistan, shortage of green forage is one of the limiting factors to maintain present livestock population. This shortage is about 40-50 percent which reaches up to 75 percent in fodder lean period i.e. May-June and November-December (Sarwar *et al.*, 2002).

Pakistan has 21 million hectares of cultivable land but due to shortage of food, arable crops are cultivated even on marginal lands. Hence, these cultivable lands cannot be shifted permanently to forage crops (Iqbal *et al.*, 1998). Although about 1/6th of the total cropped area in Pakistan is put under forage crops annually but animals are generally under fed because of lesser supply of available forage supply which is less than actually needed (Hussain *et al.*, 1993).Under such conditions the evolution of high yielding and good quality (in respect to protein contents) forage crops especially the leguminous fodder crops is dire needed to bridge the production and demand gaps especially during the scarcity periods. Leguminous forages are not only rich in protein but also in minerals and vitamins B (Hill and Curse, 1992). Other advantages of forage legumes are: increase soil fertility, control soil erosion as it covers the soil (Ahmed and Anwar, 1986; Khan *et al.*, 1986).

Moth bean, also known as moth, mat bean, matki bean, mout bean, or dew gram is an indispensable component of dryland farming system in arid and semi-arid regions. The crop is used as fodder and green manure. Its fodder is mixed with millets to make nutritious and palatable fodder for cattle (Yadav *et al.*, 2004). The production potential of this crop can be improved by using organic manures along with inorganic fertilizers (Singh and Kumar, 2009). Chemical fertilizers play an important role to meet nutrient requirement of the crop but continuous use of these on lands will have deleterious effects on physical chemical and biological properties of soil, which in turn reflects on yield (Sarkar *et al.*, 1997). Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase the usage of organic manures which are known to improve physico-chemical properties of soil and supply the nutrients in available form to the plants.

Phosphorus (P) is a universally deficient plant nutrient particular in light textured soils where most of the moth bean is grown. Application of P to pulse crops has been found very effective and called as master key element for increasing the fodder yield. Amongst the various factors limiting the plant growth, P deficiency is recognized major bottleneck in

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realizing the full yield potential of moth bean (Patel *et al.*, 2004). Phosphorus is responsible for the growth and development of roots and had favorable influence on legumes nodulation (Tang *et al.*, 2001). Phosphorus fertilization to legumes is more important than that of nitrogen because later is being fixed by symbiosis with Rhizobium bacteria. Phosphorus plays a significant role in the formation of energy rich phosphate bond like ADP and ATP, nuclear protein and phospholipids. Phosphorus fertilization also improves the quality of seeds and serves the dual purpose of increasing yield of main crop as well as succeeding crops (Abel *et al.*, 2002). Phosphorus is one of the most important elements that significantly affect plant growth and metabolism thus its deficiency limits legume production in most agriculture soils (Shu-Jie *et al.*, 2007).

Phosphorus along with Rhizobium inoculation increased growth, yield and nitrogenase activity as well as improved soil fertility for sustainable agriculture (Fatima *et al.*, 2007). Mung bean can be successfully grown under limited water supply when at least two irrigations are given with phosphorus fertilizer (Malik *et al.*, 2006). NPK fertilizers and inoculation with Brady rhizobium enhanced nodulation shoot fodder yield (g m^{-2}) and grain yield of mash bean (Javid *et al.*, 2006).

Inoculation with suitable rhizobia along with phosphorus improves symbiotic nitrogen fixation and yield in common bean (Zaman-Allah *et al.*, 2007). Low P availability is especially problematic for leguminous crops, since legume nodules responsible for N^2-fixation have a high P requirement (Vance, 2001). Application of OM enhance the fertility of soil and crop production by changing the physiochemical properties of soil including bioavailability of nutrients, water holding, cation exchange capacity, soil pH, microbial population and activity etc. (Negassa *et al.*, 2001; Walker *et al.*, 2004; Clemente and Bernal, 2006; Muhammad and Khattak, 2009) and yield (Abraham *et al.*, 2002). The chemical properties of soil are affected by the addition of OM through different organic amendments and change in soil pH (Walker *et al*l., 2004). As the substantial effect of manures remain for longer time in the soil, the nutrients releases slowly and become available to the plants gradually (Singh *et al.*, 2014; Malival, 2001 and Das, 2002). Amanullah *et al.* (2016) recently reported that growing common bean and maize as sole crops are in intercropping had better growth and higher yield and land equivalent ratio in the field under organic matter (compost) application than the field where no compost was applied.

In the arid and semi-arid regions, water deficit is the main factor that limits crops performance. Limitation of water source, irregular annual rainfall during growth season and lack of sources management cause severe decreasing in crops yield (Amanullah *et al.*, 2015). There is lack of research to study the impact of integrated use of phosphorus and organic sources on the fodder production of moth bean. This research was therefore designed with an objective to study the influence of integrated management of phosphorus and organic matter sources aiming at better growth and higher fodder yield of moth bean under both irrigated and dryland conditions.

MATERIALS AND METHODS

To study the effect of phosphorus (P) and different organic matter (OM) sources on growth and fodder production of moth bean with and without irrigation, field experiment was conducted at the Agronomy Research Farm of The University of Agriculture Peshawar, during summer 2014. The experiment consisted of three levels of P (30, 45 and 60 kg ha^{-1}), three OM sources (Canola straw, Berseem straw and Farmyard manure each applied at the rate of 5 t ha^{-1}), under two field conditions: (i) with irrigation (ii) without irrigation. The experiment was laid out in a randomized complete block design having three replications. Each replication consisted of 10 treatments per replication with a plot size of 2 m x 2 m (4 rows, 2 m long) were used. A local variety of moth bean was used and sown on 15th July, 2014. Data were recorded on number of leaves $plant^{-1}$, plant height, number of main branches $plant^{-1}$, number of sub branches $plant^{-1}$, fresh and dry fodder yield (g m^{-2}). Data on plant height (cm) was recorded with the help of meter rod by selecting five plants randomly from each plot and then average was worked out.

Number of leaves, main branches and sub branches $plant^{-1}$ were recorded by counting its number $plant^{-1}$ respectively. Data on fresh fodder yield (g m^{-2}) was recorded by harvesting two central rows in each plot and then weight it with help of digital balance. After recording the fresh fodder yield (g m^{-2}) the samples were then kept in oven for about 70 ^{0}C for 48 hours, after complete drying their dry weight was taken with help of electronic balance and their average was calculated.

Statistical analysis

The data were statistically analyzed according to Steel *et al.* (1996) for randomized complete block design and means among different treatment were composed using least significant differences (LSD) test ($P \leqslant 0.05$).

RESULTS AND DISCUSSION

Control versus treated plots (rest)

The phosphorus and organic matter treated plots (rest) had better growth and had produced higher fresh and dry fodder yield than control (Table 1). Statistical analysis of data revealed that number of leaves $plant^{-1}$, plant height, number of main branches $plant^{-1}$, number of sub branches $plant^{-1}$, fresh fodder yield (g m^{-2}) and dry fodder yield (g m^{-2}).of moth bean was significantly affected by control vs. rest. The treated plots (rest) had significantly maximum number of 44.3 leaves plant-^{1} than control (37.2). Plant height of 55.3 cm was recorded from the treated plots, which is significantly higher than control (50.0 cm). The treated plots (rest) had significantly maximum number of 5.2 main branches plant-^{1} than control (3.5), similarly maximum number of sub branches $plant^{-1}$ 18.2 was noted in the rest plots as compared to control (15.0). The treated plots (rest) had significantly maximum fresh and dry fodder yield (831 g m^{-2}) and (281 g m^{-2}) than control (792 g m^{-2}) and (242 g m^{-2}) respectively. Phosphorus encourages the formation of new cells, promotes plant vigour and root growth, hastens leaf development which helps in harvesting more solar energy and later utilization of nitrogen and application of organic manures may enhance the fertility of soil and crop production by changing the physio-chemical properties of soil which can be attributed for the greater plant height and number of branches per plant and fodder yield of moth bean. Singh and Singh (2012) recorded that the application of 75 kg P_2O_5 ha^{-1} recorded the maximum leaf area, plant height and LAI of pigeon pea over control. Sammauria *et al.* (2009) while working at Bikaner observed that application of P_2O_5 significantly increased the plant height of cluster bean.

Dry matter production increased in response to increasing phosphorus fertilizer. While the lowest dry matter production was recorded for P_0 (control) application (Erkovan *et al.*, 2010). Yadav (2001) also reported that application of FYM significantly increased the number of leaves, plant height and dry matter production of cowpea over control. Netwal (2003) found significantly higher plant height and number of branches plant-[1]of cowpea due to application of vermicompost and FYM at 5 t ha^{-1} as compared to control. Reddy and Swamy (2000) reported that application of FYM at 10 t ha^{-1} increased the dry matter per plant of black gram to the extent of 8.3 per cent over control.

Table 1: Growth and yield attributes as affected by phosphorus levels (kg P ha-1) and sources of organic matter (each 5 t ha-1) with and without moisture stress

Treatments	Number of leaves $plant^{-1}$	Plant height (cm)	Number of main branches $plant^{-1}$	Number of sub branches $plant^{-1}$	Fresh weight (g m^2)	Dry weight (g m^2)
30 kg ha^{-1}	41.7	53.7	4.8	17.7	822.1	272.1
45 kg ha^{-1}	42.9	55.3	5.0	18.1	830.0	280.0
60 kg ha^{-1}	48.3	56.9	5.7	18.8	842.3	292.3
$LSD_{0.05}$	1.2	0.40	0.5	0.4	2.3	2.3
Organic Sources						
Canola straw	42.4	54.0	4.8	17.5	819.3	269.3
Berseem straw	44.7	55.4	5.2	18.3	834.8	284.8
FYM	45.9	56.4	5.5	18.8	840.3	290.3
$LSD_{0.05}$	1.2	0.40	0.5	0.4	2.3	2.3
With Irrigation	49.8	56.3	5.5	18.6	833.1	283.1
Without Irrigation	38.9	54.2	4.9	17.8	829.8	279.8
$LSD_{0.05}$	1.1	1.17	0.7	0.2	0.4	0.4
Control	37.2	50.0	3.5	15.0	791.8	241.8
Treated plots	44.3	55.3	5.2	18.2	831.5	281.5
Interactions						
P x OM	*(Fig.1)	*(Fig.2)	ns	ns	ns	ns
Irrigation x P	ns	*(Fig.3)	ns	ns	ns	ns
Irrigation x OM	ns	ns	ns	ns	ns	ns
Irrigation x P x OM	ns	ns	ns	ns	ns	ns

Means of the same category followed by different letters are significantly different from each other using LSD test ($P \leqslant 0.05$).
Where * stands for significant and ns stands for non-significant interactions ($P \leqslant 0.05$).

Irrigated versus dryland condition

The moth bean planted under irrigated condition had better growth and had produced higher fresh and dry fodder yield than moth bean under dryland condition (Table 1). The maximum number of leaves $plant^{-1}$ (49.8) was recorded from the irrigated as compared to dry land condition which are (38.9). Taller plants (56.3 cm) were recorded from irrigated as compared to dry land condition which is (54.2cm). Maximum number of main and sub branches $plant^{-1}$ (5.5) and (18.6) was recorded from the irrigated as compared to dry land condition which are (4.9) and (17.8) respectively. The maximum fresh and dry fodder yield (833 g m^{-2}) and (283 g m^{-2}) was recorded from the irrigated, while minimum fresh and dry fodder yield (830 g m^{-2}) and (280 g m^{-2}) was obtained from dry land condition respectively. El-Sarag, 2013 indicated that increasing water stress levels decreased plant height, numbers of leaves and shoots per plant. The highest forage yields were obtained when cowpea plants irrigated at 100 % field capacity treatment. In this concern, Qasem and Biftu, 2010 reported that water stress at early growth stages reduced plant height, shoot dry weight, leaf area. Also, water stress during early vegetative growth reduced growth Nam *et al.*, 1998, shortened internodes and reduced rate of leaf appearance, number of expanding leaves and final leaf area per plant of wheat (Boem and Thomas, 1998) and cellular expansion resulting from decrease in plant water content and turgor pressure (Kramer and Boyer,1995).

Phosphorus levels

The moth bean planted under the plots that received higher phosphorus level had better growth and had produced higher fresh and dry fodder yield than moth bean under low phosphorus supply (Table 1). Among the Phosphorus levels (P), the maximum number of leaves $plant^{-1}$ (48.3) followed (42.9) was recorded for the plots which received 60 kg P ha^{-1} and 45 kg P ha^{-1}, respectively, while minimum number of leaves $plant^{-1}$ (41.7) was recorded from the plots which received 30 kg P ha^{-1}. Taller plants (56.9 cm) were recorded from the plots which received 60 kg P ha^{-1}, while dwarf plants of 53.7 cm was recorded from the plots which received phosphorus at the rate of 30 kg P ha^{-1}. The maximum number of main and sub branches $plant^{-1}$ (5.7) and (18.8) was recorded for the plots which received 60 kg P ha^{-1} respectively, while minimum number of main and sub branches $plant^{-1}$ (4.8) and (17.7) was recorded from the plots which received 30 kg P ha^{-1}. Maximum fresh and dry fodder yield (842 g m^{-2}) and (292 g m^{-2}) was recorded from plots which received 60 kg P ha-[1], followed by (830 g m^{-2}) and (280 g m^{-2}) in those plots which received 45 kg P ha^{-1} while minimum fresh and dry fodder yield (822 g m^{-2}) and (272 g m^{-2}) was recorded from the plots which received 30 kg P ha^{-1}.

Phosphorus encourages the formation of new cells, promotes plant vigour and root growth, hastens leaf development which helps in harvesting more solar energy and later utilization of nitrogen which can be attributed for the greater plant height and number of branches per plant. Dry matter production increased in response to increasing phosphorus fertilizer, while the lowest dry matter production was recorded when P was not applied (Erkovan *et al*., 2010). Baboo and Rana (1995) reported that increase in phosphorus rate up to 90 kg ha^{-1} increased plant growth parameters namely dry matter accumulation of cowpea. Meena *et al*. (2002) concluded that application of 40 and 60 kg P_2O_5 ha^{-1} to cluster bean remained at par with each other and significantly increased the dry matter at harvest. Rathore *et al*. (2007) observed that application of 40 kg P_2O_5 ha^{-1} significantly improved the dry matter accumulation in cluster bean. Singh and Singh (2012) recorded that the application of 75 kg P_2O_5 ha^{-1} recorded the maximum dry matter production plant^{-1} of pigeon pea which were significantly superior over control. Brar *et al*. (2003) reported that the crop responded significantly to applied P in dry matter production.

Organic sources

The moth bean grown under the plots that received farm yard manure as source of organic matter had better growth and had produced higher fresh and dry fodder yield than moth bean grown under berseem and canola residues (Table 1). Among the OS (organic matter sources), the maximum number of leaves per plant^{-1} (45.9) was recorded for the plots treated with farmyard manure, followed by (44.7) with berseem straw, while minimum number of leaves plant^{-1} (42.4) was recorded from the plots that received canola straw. Taller plants (56.4 cm) were recorded for the plots treated with farmyard manure, followed by (55.4 cm) with berseem straw application, while dwarf plants of 54.0 cm were recorded from the plots that received canola straw. Maximum number of main and sub branches plant^{-1} (5.5) and (18.8) was recorded for the plots treated with farmyard manure, which was statistically same to (5.2) and (18.3) with application of berseem straw, while minimum number of main and sub branches plant^{-1} (4.8) and (17.5) was recorded from the plots that received canola straw respectively. Application of farmyard manure produced maximum fresh and dry fodder yield (840 g m^{-2}) and (290 g m^{-2}), followed by (835 g m^{-2}) and (285 g m-2) with application of berseem straw, while minimum fresh and dry fodder yield (819 g m^{-2}) and (269 g m^{-2}) was recorded from the plots that received canola straw respectively. Application of OM enhance the fertility of soil and crop production by changing the physiochemical properties of soil including bioavailability of nutrients, water holding, cation exchange capacity, soil pH, microbial. Reddy and Swamy (2000) further reported that application of FYM at 10 t ha-^{1} increased the dry matter per plant of black gram to the extent of 8.3 per cent over control. Yadav (2001) at Jobner also reported that application of FYM significantly increased the dry matter accumulation per meter row length of cowpea over control. Das *et al*. (2002) reported that application of vermin compost showed better influence on dry matter yield of green gram compared to chemical fertilizers used.

Interaction

Phosphorus into organic matter sources (OS) interaction indicated that application of farmyard manure as organic source with phosphorus at the rate of 60 kg ha^{-1} produced maximum number of leaves plant^{-1} as shown in Fig. 1. Phosphorus into organic sources interaction indicated that application of farmyard manure as organic sources with phosphorus at the rate of 60 kg ha^{-1} produced taller plant height as shown in Fig. 2. Irrigation into phosphorus interaction showed that application of phosphorus at the rate of 60 kg ha^{-1} with irrigation produced taller plants in moth bean as shown in Fig. 3.

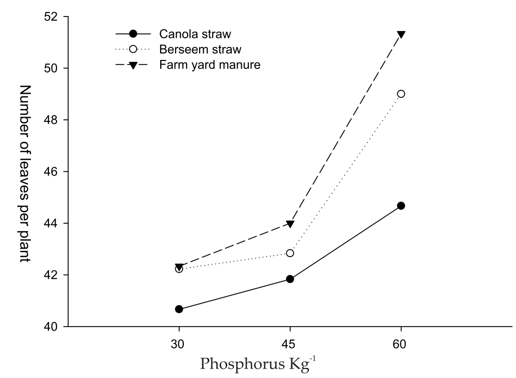

Fig.1: Interaction between phosphorus levels and organic sources influence number of leaves per plant in moth bean.

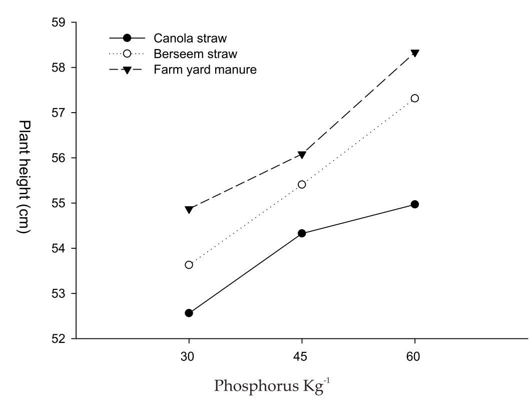

Fig.2: Interaction between phosphorus levels and organic sources influence plant height (cm) in moth bean.

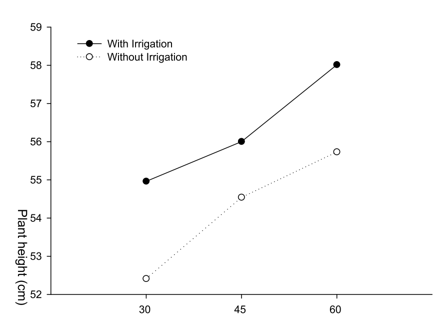

Fig. 3: Interaction between phosphorus levels and irrigation influence plant height (cm) in moth bean.

CONCLUSIONS

Under semiarid climates, higher rate of phosphorus application improve growth and fodder yield under irrigated and dryland conditions. Incorporation of farmyard manure was also found beneficial in term of better growth and higher fodder yield than plant residues incorporation under irrigated and dryland conditions. Berseem residues (legume) incorporation was found superior in term of better growth and higher fodder yield than canola residues (non-legume) incorporation.

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