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Appropriate sowing technique to enhance productivity and maximize the net return of alfalfa crop

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Abstract Alfalfa *(Medicgo sativa* L.) is a popular forage crop of Pakistan due to its multi cutting, palatable and nutritious forage quality. In Pakistan, huge gap in alfalfa yield and demand is unavoidable to be engineered. The scientific research was planned to find out suitable sowing technique for enhancing the forage and grain production and also maximize the income and net return. The study was selected five sowing methods at 15 cm, 30 cm, 45 cm, 60 cm row to row distance and Broadcast (BC). Results revealed that broadcast sowing technique produced higher values of main components of yield and enhanced forage yield by 15%, grain tonnage by 23% and net return 24.4% over control (i.e. 30 cm apart row to row). The economic data showed a highest benefit cost ratio (BCR) of 3.34 (24.6%) by broadcast technique when alfalfa sown in standing water than control (i.e. row to row 30 cm).

Keywords: Benefit cost ratio, Economic return, Fodder yield, Sowing techniques, Yield component

Introduction

Fodder grasslands consist of 26% land area out of the world and in out of agricultural area 70% under forage grassland (Anonymous, 2010). Alfalfa can be cultivated with both Tropical and temperate grasses (Capstaff and Miller, 2018) and also successfully grown for three years or more (Bélanger *et al.*, 2006). Alfalfa is a highest famous forage crop which produces highest tonnage of biomass with excellent nutritional value that is excellent for enhancing the production of meal and milk (Veronesi *et al.*, 2010). Due to its ideal fodder quality with high tonnage alfalfa is known as "Queen of the forages" in several countries of world (Yuksel *et al.*, 2016). It provides minerals, fiber, energy and protein (Kamalak and Canubolat, 2010; Kiraz, 2011). Alfalfa due to its high protein, is a high rich source of mineral substances and several vitamins (Geren *et al.*, 2009). Hay of alfalfa has

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considerably maximum digestibility coefficients for crude protein, crude fiber, fat and organic matter as compared to other grasses (Sommer *et al*., 2005). The significant deficit in fresh forage production and demand exists which require to be decreased to carry on with requirements of fast-growing sector of livestock. Livestock being allied sector of agriculture shares about 11.5% in GDP that is 60.1% contribution of agriculture to GDP (GOP 2020-21). Because of shortage of quality forage, animals of livestock remain below nourished which resulted decrease in production. Farmer's unawareness about optimum crop stand, fodder high yielding varieties and production technologies are main factors in Pakistan for forage low yield (FRI 2018-19). The main gap in fodder production and requirement couples to the adaptability of appropriate techniques of cultivation to reduce this gap. Sowing of high yielding varieties under appropriate cultivation techniques can enhance forage tonnage (Nawaz, 2017). Cultivation methods influence the plant density, development of root and plant growth by modulating competition between plants, spatially plant distribution and resources acquisition (Shahzad *et al.*, 2016; Dabhi, 2017). Choubey *et al*. (1991) investigated the influence of cultivation techniques on fodder and grain tonnage and observed that broad cast technique can produce higher green forage and dry matter. Low forage tonnage and less availability of feed are main limiting factors to enhancing the productivity of livestock in our country (Pakistan). Development of livestock depends upon accessibility of appropriate quantity and quality feed for livestock (Amanullah *et al*., 2005). In our country, alfalfa is the very important fodder crop and the availability of alfalfa grain production is necessary in agricultural sector. The high quality grain material availability, according to required quantities is the main factor for successful tonnage of forage on cultivated grassland. Today, local production of alfalfa grain is very low as compared to requirement of country. Therefore, we import the seed from other countries. In addition, enhanced import of lucern grain have a negative effect on our country's payment balance. The production of alfalfa grain in Pakistan range between about 50-100 Kg ha^{-1}, usually 300-500 Kg ha^{-1}. Sowing techniques is the most important factor in alfalfa seed production (Vučković, 2004). The major scientific aim of this study was to determine most favorable model to achieve maximum and stable production of alfalfa fodder and seed of good quality. Another aim was to increase net return based on the examination of the effect of different sowing techniques.

Materials and methods

Experiment site

The scientific research trial was conducted for three years in winter season of 2015-16 to 2017-2018 at Fodder Research Farm Sargodha,

Punjab, Pakistan. The means of annual precipitation of research area was noted as 390, 410, 430 mm during 2016, 2017 and 2018 respectively. The soil of research farm was loam with organic matter 0.61%, pH 7.8 ± 0.10 N% 0.06, K+174 and P 5.6 ± 0.42 (Gondal *et al.*, 2021). The soil status were find out by using standard principles.

Experiment lay out

The scientific research consisted on five techniques of sowing i.e. Broadcast method (SM_1), drilling methods with row to row distance 15 cm (SM_2), 30 cm (SM_3), 45 cm (SM_4) and 60 cm (SM_5).

Experiment area was cultivated by one deep ploughing and two normal cultivation with planking, then pre-soaking irrigation except treatment plots of broadcast technique. After this when level of proper moisture for "watter" maintained, seed bed was prepared for sowing. Randomized complete block design (RCBD), consisting of four replicates was used and net plot kept 3.6 m × 6.0 m for every treatment. Sowing was completed in last week of October every years by using seed 10 kg per hectare of alfalfa cultivar "Sargodha Lucern 2002". In broadcast treatments, in standing water uniformly seed was broadcasted and other treatment were sown with the help of hand drill on the same day in watter condition. In all treatments fertilizer NPK was applied @ 57-57-57 kg per hectare. Out of which full dose of P & K and half N were used at the preparation of seed bed and second dose of half nitrogen was used after 30 days of sowing.

Crop harvesting and collection of data

When crop reached at 60 cm height, about 55 to 60 days after sowing, first cut was achieved from BC technique and after 95 days of sowing, other all treatments including BC method reach up to 60 cm height then first cut of SM_2, SM_3, SM_4, SM_5 was taken and 2nd cut of BC method so that from BC method obtained one extra cut at start. All other succeeding cuts were obtained when plants normally achieved 60 cm height, each time during first year, four cuts of fodder were taken upto 20th April and after that crop was left for seed setting upto 31st July each year of study.

Ratoon crop again left for fodder to next year and fertilizer with irrigation applied and get six cuts up to next year 20th April and after again crop left for seed setting up to 31st July. The same process was repeated in third year of study. With the help of spring balance in the field after each cut, green forage tonnage per plot was obtained and then converted forage yield into ton per hectare. Seed yield components such as height of plant (took with meter rod), productive tillers (counted from each plot per square meter), stem thickness (took with vernier caliper), pods per raceme and seed per pod were taken when crop achieved 70% maturity stage. Thousand grain

weight and seed yield were taken after threshing of crop separately from each plot.

Net income

Net income was estimated by subtracting the total expenditures of different operations (such as land rent, preparation of seed bed, tillage, labour, seed, and fuel etc.) involved in sowing to harvesting of crop from total income of fodder and seed estimated according to prevailing selling rates of market (i.e. Rs. 150 per 40 kg of fodder and 1000 per kg of seed) for green fodder and grain.

Statistically data analysis

All the research trial data recorded were analysed through method described by Steel and Torrie (1997). The average of variance were compared with each other through LSD test at 5 percent probability level (Gomez and Gomez 1984).

Results

The results of all parameters i.e. attributes of yield, forage and seed yield showed considerable differences among all sowing techniques. During entire investigation period consisting on three years, similar trends were noted in all growth components and sowing techniques. Broadcast sowing technique contributed maximum forage and seed yield with maximum net return than all other sowing techniques during study period 2015-16 to 2017-2018 (Table 1, 2 and 3). Considering growth parameters, in broadcast (BC) cultivation technique plant height reduced as compared to all other sowing techniques. Maximum height (91 cm) of plant was observed in 60 cm apart row to row and minimum (76 cm) from broadcast method which is statistically at par to 15 cm apart row to row (Table-1).

Broadcast sowing method contributed maximum tillers m^{-2} (502) and tillers subsequently decreased upto SM_5 (60 cm) apart lines which produced 297 tillers m^{-2} that was statistically at par with SM_4 (310) and also BC method followed by SM_2 which produced 445 tillers m^{-2}.

Maximum pods per raceme (60) were showed by BC sowing method that was statistically at par with 15 cm (SM_2) row to row spacing (56). The lowest number of pods per raceme (45) were recorded in sowing method 60 cm row to row which was at par to sowing technique 45 cm row to row distancing that produced 48 pods per raceme (Table-1). Each sowing technique showed statistically significant differences when data was compared. Broadcast technique produced highest seeds per pods (3.92) which was statistically at par with SM_2 which produced 3.89 seeds per pods.

The lowest seeds per pod 2.99 was produced by SM_5 60 cm row to row distance (Table-1).

Sowing techniques had considerable effect on 1000 grain weight. Statistically highest weight (2.093 g) was achieved form broadcast sowing technique that was followed by SM_2 15 cm row to row, which showed 2.01 g. Least weight of 1000 grain weight (1.89 g) was achieved by SM_5 60 cm apart lines (Table-1). Considering stem thickness, all sowing techniques showed significant differences as among each other. Broadcast method showed highest stem thickness (2.05 mm) that was statistically same with the stem thickness (1.99 mm) of SM_2, 15 cm row to row distance. Least stem thickness (1.817 mm) was obtained from SM_5, 60 cm row to row (Table-1).

Fodder and seed yield

Yearly and average data of there years (2015-16, 2016-17 and 2017-18) showed that highest green forage tonnage (28, 67, 70 t ha^{-1} yearly and 55 t ha^{-1} average respectively) was produced from SM_1 (broadcast method) which was considerable at par with sowing method SM_2 15 cm row to row distance for 2016-17 and 2017-18 (66, 68 t ha^{-1} respectively) and followed by 2015-16 and average data (28, 52.75 t ha^{-1}) respectively (Table-2). Least green fodder yield (14, 50, 48 t ha^{-1}) yearly during 2015-16, 2016-17 and 2017-18 respectively and average 37.25 t ha^{-1} was obtained from SM_5 60 cm row to row distance (Table-2).

Amongst sowing techniques, it was estimated that broadcast sowing (SM_1) produced maximum seed tonnage during 2015-16 (205 kg ha^{-1}), 2016-17 (265 kg ha^{-1}) 2017-18 (365 kg ha^{-1}) and an average of three years 278 kg ha^{-1} which was followed by SM_2 15 cm row to row distance. Least seed production was achieved form SM_5 60cm row to row distance which produced grain yield during 2015-16 (112 kg ha^{-1}) 2016-17 (148 kg ha^{-1}) 2017-18 (225 kg ha^{-1}) and an average of 161 kg ha^{-1}.

Economics of forage and grain per unit area

The main income from alfalfa crop achieved by seed production. Although income from fodder was as compared to seed was low but forage production is very essential to ensure availability of forage for livestock and to reduce cost to cultivation of farmers for next season. Highest gross income from forage and grain (Rs. 484500/-) was achieved from broadcast sowing method (SM_1) technique with net return of Rs. 339500/- and BCR 3.34. While minimum gross income from forage and grain (Rs. 301187/-) was obtained from SM5 60 cm row to row distance along with net income of Rs. 156187 and BCR 2.07.

Discussion

In present scientific study, five sowing techniques were used to enhance the production (fodder and seed) and net return of alfalfa crop per unit area. Under the present study, broadcast sowing method improved the yield components. That is in agreement with previous investigation that might be due to uniformly distribution of seed and proper maintenance of plant to plant distance that increased aeration, nutrients, water uptake and improve growth environment (Schmierer *et al.*, 1997; Abdullah *et al.*, 2008; Khan *et al.*, 2012) when seed uniformly distributed by broadcasting then plant to plant distance maintained, due to which competition between plants for air and light decreased, plant height decreased and lodging rate reduced. Gondal *et al.* (2017) also reported that plant height increased due to competition of light in plants.

Elhag (2007) also observed maximum height of plant, plant density, leaf to stem ratio in alfalfa when sown by broadcasting seed on ridges. Karagic *et al.* (2008) also reported that insect pollination of alfalfa badly influenced when crop lodged due to maximum growth rate and grain yield decrease. Increased forage yield seed tonnage and BCR in broadcasting technique as compared to row spacing sowing. This might be because of proper plant to plant distance efficient nutrients and light utilization, reduction in lodging, pollinators activity, improved aeration and irrigation by plants as indicated by Soomro *et al*., (2009) and Hameed *et al*. (2014). Mustafa, (1996) observed that plant population of alfalfa enhanced when cultivated on ridges by broadcasting grain. Gondal *et al*. (2021) reported that broadcast technique provide maximum fresh fodder and dry herbage tonnage when compared with row to row spacing technique. Gaballah (2006) and Dabhi (2017) also reported the same findings that broadcast showed maximum fodder tonnage. Arora *et al.* (1998) indicated that highest grain tonnage was obtained by broadcast sowing method as compared to row spacing sowing.

Gondal *et al*. (2021) also reported that berseem crop in BC method provided higher number of heads m^{-2}, maximum 1000 seed weight and grain yield as associated with row sowing. Highest benefit cost ratio calculated from broadcast sowing technique was because of maximum fresh forage tonnage and grain yield with respect to drill sowing technique (Hussain *et al*., 2015).

Alfalfa is a very important forage of Pakistan that is used for feeding of animals. Fast growing sector of livestock need more forage. In our country no remarkable research work has been conducted for testing of sowing techniques so that present investigation is fully a novel study of its type in which broadcasting technique compared with line sowing. Conclusively, research experiment results revealed that alfalfa cultivar "Sargodha Lucern 2002" when sown in standing water by broadcasting seed

uniformly and left for grain setting on 20th April after taking the last cut of fodder, provides highest fodder, seed yield and also maximum net income as compared to drill sowing.

Table 1. Influence of sowing techniques on yield parameters

Techniques	Plant Height (cm)	Tillers (m^{-2})	Stem Thickness (mm)	Pods/Raceme	S/Pods	1000 Seeds Weight (g)
Broadcast SM_1	76 bc	502 a	2.05 a	60 a	3.92 a	2.097 a
15 cm apart SM_2	78 bc	445 b	1.99 ab	56 ab	3.89 a	2.01 b
30 cm apart SM_3	81 bc	351 c	1.93 bc	53 bc	3.64 b	1.95 bc
45 cm apart SM_4	85 ab	310 d	1.91 c	48 cd	3.27 c	1.91 c
60 cm apart SM_5	91 a	297 d	1.82 d	45 d	2.99 d	1.89 c
LSD	7.27	36.74	0.067	5.27	0.094	0.067

Table 2. Influence of sowing techniques on forage and seed yield of alfalfa

Techniques	Fodder Yield (t /ha)				Seed yield (kg/ha)			
	2015-16	2016-17	2017-18	Average Yield	2015-16	2016-17	2017-18	Average Yield
Broadcast SM_1	28 a	67 a	70 a	55 a	205 a	215 a	365 a	278 a
15 cm apart SM_2	22 b	66 a	68 a	52.25 b	186 b	191.75 b	293 b	224 b
30 cm apart SM_3	19 c	62 b	60 b	46.75 c	170 b	189.75 b	282 b	214 b
45 cm apart SM_4	17 d	57 c	54 c	42.5 d	146 c	180 b	246 c	191 c
60 cm apart SM_5	14 e	50 d	48 d	37.25 e	112 d	148 c	225 d	161 d
LSD	1.66	3.35	3.79	2.062	18.178	15.228	19.714	11.213

Table 3. Economic comparison of sowing techniques

Techniques	Cultivation cost/ha (Rs.)	Fodder Yield (T/ha)	Seed Yield (kg/ha)	Fodder Income (Rs.)	Seed Income (Rs.)	Gross Income (Rs.)	Net Income (Rs.)	BCR
Broadcast SM_1	145000	55	278.25	206250	278250	484500	339500	3.34
15 cm apart SM_2	145000	52.25	224.0	195937	224000	419937	274937	2.89
30 cm apart SM_3	145000	46.75	214.0	175312	214000	389312	244312	2.68
45 cm apart SM_4	145000	42.5	191.0	159375	191000	350375	205375	2.41
60 cm apart SM_5	145000	37.25	161.50	139687	161500	301187	156187	2.07

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