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# FORAGE AND SEED PRODUCTIVITY OF OAT AND ALFALFA AS INFLUENCED BY DIFFERENT NITROGEN-PHOSPHORUS COMBINATIONS AND FOLIAR BORON NUTRITION

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Broadcast, foliar application, growth stages, nitrogen application, yield, wheat

## ABSTRACT

***Background*** Adequate nutrition of plants is vital for optimum growth, yield and quality. Present study investigated the effect of different combinations of nitrogen (N) and phosphorus (P), and foliar boron (B) nutrition for optimum forage and seed yield of oat and alfalfa under agro-ecological conditions of Sargodha, Pakistan.

***Methodology*** This study comprised of two independent field experiments. In first study, two year field experiment was conducted to find out most appropriate N-P combination for obtaining optimum forage yield of oat. Treatments consisted of six N-P combinations viz., 0-0, 40-28, 52-56, 64-28, 76-56, 88-56 and 100-56 kg $ha^{-1}$ N and $P_2O_5$, respectively. Oat variety (cv. S-2000) was sown. In second study, two year field experiment was carried out to find out appropriate level of boric acid as foliar application for optimum seed yield of alfalfa. Treatments included two foliar spray of 0, 2, 4, 6, 8 and 10 g $L^{-1}$ boric acid solutions, 1st at intensive growth stage and the 2nd at the beginning of blossoming. Alfalfa variety (cv. Sargodha Lucerne) was used. ***Results*** In the first study, maximum green fodder yields (63.0 and 60.7 t $ha^{-1}$) and dry matter yields (11.8 and 10.2 t $ha^{-1}$) of oat during first and second year of study, respectively along with the highest net income of Rs.12626 were recorded with 100-56 kg $ha^{-1}$ N-$P_2O_5$, respectively. In the second study, the highest number of seeds per pod (4.9 and 6.8 in first and second year, respectively), 1000-seed weight (0.63 and 0.77 g in first and second year, respectively) and seed yield (168.7 and 312.1 kg $ha^{-1}$ in first and second year, respectively) of alfalfa were observed with 8 g $L^{-1}$ boric acid foliar spray. The same treatment also gave maximum benefit-cost ratio of 17.24.

***Conclusion*** The most appropriate N-P combination for getting maximum forage yield of oat was 100-56 kg $ha^{-1}$, whereas foliarly applied boric acid at a concentration of 8 g $L^{-1}$ boric acid produced the highest seed yield and economic returns.

## INTRODUCTION

Oat (*Avena sativa* L) is an important winter season fodder under irrigated conditions sown either as independent crop or mixed cropped with berseem. Oat provides nutritious fodder in dry months, and are relished by all animals particularly horses and mules. When mixed with berseem, oat provides balanced feed to milch animals. In the past, efforts were made to improve the fodder yield through the use of nitrogen (N), phosphorus (P) and potash (K) fertilizers. Vyas et al. (1988) reported that increasing N (0, 40, 80 and 120 kg $ha^{-1}$) and $P_2O_5$ (0, 30 and 60 kg $ha^{-1}$) rates increased the fresh and dry matter yields significantly. Collins et al. (1990) concluded that N application up to 84-112 kg $ha^{-1}$ increased forage yield and plant N content of oat. Tripathi et al. (1991) found that fodder yield of oat was higher where 50% urea + 50% FYM

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and single super phosphate were applied compared to control. Mirza et al. (1992) reported oat cultivars fertilized with NPK at 120-60-30 kg ha$^{-1}$ gave significantly higher fodder yields than 90-60-30 NPK kg ha$^{-1}$. Sood and Kumar (1994) found that yield of oat and berseem mixture was increased by applying N at 75 kg ha$^{-1}$ and $P_2O_5$ 75 kg ha$^{-1}$. Primavesi and Primavesi (1996) recorded that application of 40 kg N ha$^{-1}$ gave the highest forage and dry matter yields. Efficiency of N utilization decreased with increasing rates of application. Desale et al. (2000) reported that NPK @ 12-70-22 kg ha$^{-1}$ applied to berseem and 75-30-30 NPK kg ha$^{-1}$ to oat gave significantly ($p\leq 0.05$) more green forage, dry matter and crude protein yields, and also the highest economic returns of crop was recorded.

Alfalfa (*Medicago saliva* L.) is a popular fodder crop throughout the world, and is used for grazing, green chop, silage and hay to support the livestock industry, including dairy, beef, horses, and sheep. Its seeds are produced primarily for the reproduction of forage crop. The agro-management practices for its seed production quite differ from those needed for forage production. As it is primarily sown for forage, the seed yield and quality of alfalfa usually remain low (Dordas 2006). Irrigation must be carefully controlled to stress the plants to encourage flowering and seed production. Insect pests, especially lygus bugs are managed throughout the season. The fertilizer requirements especially boron (B) for good seed production of alfalfa are somewhat higher than demanded by the good forage yield. There are several reports in number of crops which demonstrate that B can be deficient, and has a significant effect on yield even when there are no vegetative signs of deficiency and even when B concentration is at adequate range (Nyomora et al. 1999; Dordas 2006). Crops with higher B requirements such as alfalfa, sunflowers, rapeseed, cauliflower and apples are most likely to respond to B. It is also needed for the growth of the pollen tube during flower pollination, and is therefore important for good seed set and fruit development. Boron is thought to increase nectar production by flowers, and this attracts pollinating insects. A very little work has yet been reported regarding whether there is an increase in seed yield of alfalfa as a result of soil or foliar applications of fertilizer containing both major and minor elements. Dordas (2006) reported that there was an increase in alfalfa seed yield with B foliar applications.

Keeping in view the need of determining the most suitable and economical dose of N and P for the maximum forage yield of oat and investigate the effect of B foliar fertilization on seed yield of alfalfa under agro-ecological conditions of Sargodha, two separate studies were planned and executed.

## MATERIALS AND METHODS

### *Experiment 1*

For determining the optimum dose of N and P to get maximum economic yield of oat, a field experiment was conducted at Fodder Research Institute, Sargodha, Punjab, Pakistan. The soil of the experimental site was loam having pH 8, total soluble salts 0.16%, organic matter 0.44% and available P 6.2 mg kg $^{–1}$. The treatment combinations were 0-0, 40-28, 52-56, 64-28, 76-56, 88-56 and 100-56 kg ha$^{-1}$ N-$P_2O_5$, respectively. The trial was laid out in randomized complete block design with three repeats having a plot size of 3 m × 7 m. Oat variety (cv. S-2000) was sown using seed rate of 32 kg ha$^{–1}$. Seed was drilled in lines with 45 cm apart rows. All N and P in the form of urea and triple super phosphate were applied at the time of sowing. At 50% flowering stage, the crop was harvested and green fodder yield was recorded. Dry matter yield was calculated after drying the sub samples in the oven at 70 ºC. The data were statistically analyzed using Fischer's analysis of variance technique (Steel et al. 1997) and least significant test (LSD) at 5% probability level was employed for treatment means separation. Economic returns in terms of net income and benefit cost ratio were also calculated.

### *Experiment 2*

To ascertain the effect of foliar B application on alfalfa seed yield, a field experiment was conducted at Fodder Research Institute, Sargodha-Punjab, Pakistan. The soil of the experimental site was loamy having 8 pH, 0.63 mS cm$^{-1}$ EC, 0.68% organic matter, 127 mg Kg$^{-1}$ available K, and 0.55 mg Kg$^{-1}$ available B. Treatments included two foliar applications of B as 0, 2, 4, 6, 8 and 10 g L$^{-1}$ boric acid solutions, first at intensive plant growth stage and second at the beginning of crop blossoming. The trial was laid out in randomized complete block design with three repeats having a plot size of 18 m$^2$. The basal dose of fertilizer was applied as 23, 80 and 50 kg ha$^{-1}$ N, P and K, respectively at the time of sowing. Alfalfa variety (cv. Sargodha lucerne*)* was sown at a seed rate of 5 kg ha$^{-1}$. Seed was sown by hand drill. After final cutting of alfalfa for green fodder yield, the crop was allowed to mature for seed production. Dilute solutions of boric acid as per treatment were applied with 250 L of water ha$^{-1}$ as each foliar spray. The data was statistically analyzed using Fischer's analysis of variance technique (Steel et al. 1997) and LSD at 5% probability level was used for comparing treatment means.

## RESULTS AND DISCUSSION

### *Experiment 1*

The green fodder yield of oat at various N and P application rates differed significantly (Table 1). The results of average fodder yield of two years revealed that the highest N-P levels (100-56 N and $P_2O_5$ kg $ha^{-1}$) out-yielded than all other treatments by giving 63.05 and 60.77 t $ha^{-1}$ green fodder yield during first and second year of study, respectively. However, it remained statistically at par with the second highest N-P application rate (88-56 N and $P_2O_5$ kg $ha^{-1}$). The control treatment attained the minimum green forage yield (32.3 and 35.8 t $ha^{-1}$ during first and second year of study, respectively). In case of dry matter yield, the trend of fertilizer response was similar (Table 2) as depicted in case of green fodder yield. Maximum dry matter yields (11.8 and 10.2 t $ha^{-1}$ in first and second years, respectively) were produced by the highest N-P application treatment (100-56 N $P_2O_5$ kg $ha^{-1}$) that did not differ significantly from treatment receiving 88-56 kg $ha^{-1}$ N and $P_2O_5$, respectively resulting in 11.4 and 10.1 t $ha^{-1}$ dry matter yields in the first and second year, respectively. The increase in yield might be due to ample availability of essential macronutrients N and P resulting in higher vegetative growth and forage yield. These results are in agreement with Vyas et al. (1988), Collins et al. (1990), Tripathi et al. (1991), Mirza et al. (1992), Sood and Kumar (1994), Primavesi and Primavesi (1996) and Desale et al. (2000).

The economic aspect of the forage production presented in Table 3 revealed that N-P application at 100-56 kg $ha^{-1}$ gave maximum net income of Rs.12624 $ha^{-1}$ which was closely followed by that calculated with N-P application at 88-56 kg $ha^{-1}$ showing net income of Rs.12551 $ha^{-1}$, indicating it to be the most profitable/economical fertilizer level.

### *Experiment 2*

Data presented in Table 4 revealed that a large variations in alfalfa seed yield and yield contributing traits were observed during the growth period. The highest number of seeds $pod^{-1}$ (4.9 and 6.8 in first and second year, respectively), 1000-seed weight (0.63 and 0.77 g in first and second year, respectively) and seed yield (168.7 and 312.1 kg $ha^{-1}$, respectively) of alfalfa were observed with 8 g $L^{-1}$ boric acid foliar spray. However, alfalfa produced the lowest number of seeds $pod^{-1}$ (4.3 and 6.1 in first and second year, respectively), 1000-seed weight (0.47 and 0.53 g in first and second year, respectively) and seed yield (161.7 and 286.5 kg $ha^{-1}$ in first and second year, respectively) in response to no foliar B application in case of control. The number of branches $plant^{-1}$ of alfalfa was significantly influenced by various boric acid treatments during first year but remain unaffected during second year. The boric acid foliar spray 4-10 g $L^{-1}$ produced significantly the highest number of branches $plant^{-1}$ (21.5-21.7). The large year differences in seed yield and yield related parameters of alfalfa were due to climatic conditions which had a major impact on seed yield of alfalfa. In first year, precipitation in February, March, April and May was 160.58 mm. However, during second year, the precipitation was dropped to 94.49 mm in the same months. Mueller et al. (2008) also reported that alfalfa seed production is well adapted to the arid climates. A warm, dry season is important to maximize seed yield and quality. It was suggested that precipitation during the growth period greatly affected the pollination of flowers and seed setting. Large variations in the climatic factors in investigation years had contributed to large differences in yield. Sapkota et al. (2019) studied the effect of foliar B application and different water regimes on the yield and quality of alfalfa. It was found that although the foliar application of B could increase B concentration in plant tissues on B-deficient soil but had no effect on protein content and yield of alfalfa.

In addition to climatic conditions during the crop growth period, the application of boric acid had also affected the yield components and seed yield. Foliar boric acid fertilization produced higher number of seeds $pod^{-1}$ in T5 (FS-BA at 8 g $L^{-1}$ + NPK) which were 6.5 and 7.1 compared to control (4.0 and 4.9, respectively.) Similar results about the effects of B fertilization on the number of seeds $pod^{-1}$ are reported by Du et al. (2009). One of the main problems in the production of alfalfa is frequent pod abortion. This might be caused by the disturbance in the distribution of assimilates (Gender et al. 1997). Dordas (2006) stated that foliar application of B affected the fertilization, development of seeds and pods and thus increased the seed yield. The author suggested that B might play a significant role to reduce the abortion of pods. Boron content in the experimental soil was 0.54 mg $kg^{-1}$ which is considered adequate (Rashid 2005). Higher seed yield in treatment receiving foliar application of 8 kg $L^{-1}$ boric acid was due to the higher number of seeds $pod^{-1}$ and seed weight which was consistent with the view that B has significance in the processes of flowering and pollination.

It was suggested that B had a direct role in flowering, pollen germination, and seed formation. However, it was not known how B could affect the yield and how it could involve in the development of

**Table 1** Green fodder yield (t ha$^{-1}$) of oat (*Avena sativa* L.) with different combinations of nitrogen and phosphorus

| Treatment | Year | | Mean of two years | Percent increase |
|---|---|---|---|---|
| | 1999 | 2000 | | |
| T1: Control (untreated) | 32.38d | 35.80f | 34.09f | – |
| T2: NP @ 40-28 kg ha$^{-1}$ | 46.03c | 43.81e | 44.92e | 32 |
| T3: NP @ 52-56 kg ha$^{-1}$ | 53.65b | 46.14d | 49.90c | 46 |
| T4: NP @ 64-28 kg ha$^{-1}$ | 48.41c | 45.58c | 47.00d | 38 |
| T5: NP @ 76-56 kg ha$^{-1}$ | 54.56b | 55.24c | 54.90b | 61 |
| T6: NP @ 88-56 kg ha$^{-1}$ | 62.57a | 59.97a | 61.27a | 80 |
| T7: NP @ 100-56 kg ha$^{-1}$ | 63.05a | 60.77a | 61.91a | 82 |

Means sharing the same letters do not differ significantly at 0.05 probability level.

**Table 2** Dry matter yield (t ha$^{-1}$) of oat (*Avena sativa* L.) with different combinations of nitrogen and phosphorus

| Treatment | Year | | Mean value of two years | Increase over control (%) |
|---|---|---|---|---|
| | 1999–2000 | 2000–2001 | | |
| T1: Control (untreated) | 5.06 e | 5.95 e | 5.51 f | – |
| T2: NP @ 40-28 kg ha$^{-1}$ | 7.20 d | 7.10 d | 7.15 e | 30 |
| T3: NP @ 52-56 kg ha$^{-1}$ | 9.47 bc | 8.00 c | 8.73 c | 58 |
| T4: NP @ 64-28 kg ha$^{-1}$ | 8.70 c | 7.57 c | 8.13 d | 48 |
| T5: NP @ 76-56 kg ha$^{-1}$ | 10.42 b | 8.80 b | 9.61 b | 74 |
| T6: NP @ 88-56 kg ha$^{-1}$ | 11.44 a | 10.01 a | 10.73 a | 95 |
| T7: NP @ 100-56 kg ha$^{-1}$ | 11.83 a | 10.20 a | 11.02 a | 100 |

Means sharing the same letters do not differs significantly at 0.05 probability level.

**Table 3** Economic return from oat green fodder with different combination s of nitrogen and phosphorus

| Treatments | Gross income (Rs. ha$^{-1}$) | Cost of production | Benefit post ratio | Net income (Rs. ha$^{-1}$) |
|---|---|---|---|---|
| T1: Control (untreated) | 13636 | 9200 | 1.48 | 4436 |
| T2: NP @ 40-28 kg ha$^{-1}$ | 17968 | 10518 | 1.71 | 7450 |
| T3: NP @ 52-56 kg ha$^{-1}$ | 19960 | 11410 | 1.75 | 8550 |
| T4: NP @ 64-28 kg ha$^{-1}$ | 18800 | 10884 | 1.73 | 7916 |
| T5: NP @ 76-56 kg ha$^{-1}$ | 21960 | 11775 | 1.86 | 10185 |
| T6: NP @ 88-56 kg ha$^{-1}$ | 24508 | 11957 | 2.05 | 12551 |
| T7: NP @ 100-56 kg ha$^{-1}$ | 24764 | 12140 | 2.06 | 12624 |

Cost of production of oat (without fertilizer ha$^{-1}$) = Rs. 9200/-, Cost of fertilizer (40–28 kg NP ha$^{-1}$) = Rs.1318/-, Cost of fertilizer (52–56 kg NP ha$^{-1}$)= Rs.2210/-, Cost of fertilizer (64-28 kg NP ha$^{-1}$) = Rs.1684/-, Cost of fertilizer (76-56 kg NP ha$^{-1}$) = Rs. 2575/, Cost of fertilizer (88-56 kg NP ha$^{-1}$) = Rs.2757/-, Cost of fertilizer (100-56 kg NP ha$^{-1}$) = Rs.2940/-, Rate of oat fodder ton$^{-1}$ = Rs. 400/-.

**Table 4** Seed yield and yield components and of alfalfa (*Medicago sativa* L.) as influenced by different boron applications

| Treatments | Number of seeds pod$^{-1}$ | | Number of branches plant$^{-1}$ | | 1000-seed weight (g) | | Seed yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | 2015–16 | 2016–17 | 2015–16 | 2016–17 | 2015–16 | 2016–17 | 2015–16 | 2016–17 |
| T1 | 4.3d | 6.1d | 21.3c | 22.2 ns | 0.47e | 0.53d | 161.7e | 286.5f |
| T2 | 4.4c | 6.3c | 21.4b | 22.3 | 0.53d | 0.57d | 167.9d | 299.2e |
| T3 | 4.5bc | 6.4c | 21.5abc | 22.3 | 0.57c | 0.67c | 171.3c | 304.6d |
| T4 | 4.5bc | 6.6b | 21.5abc | 22.5 | 0.57bc | 0.70bc | 175.0b | 308.3c |
| T5 | 4.9a | 6.8a | 21.7a | 22.5 | 0.63a | 0.77a | 186.7a | 312.1a |
| T6 | 4.7b | 6.7b | 21.6ab | 22.4 | 0.60b | 0.72b | 176.1b | 310.1b |
| LSD value | 0.23 | 0.19 | 0.26 | - | 0.029 | 0.047 | 3.10 | 1.36 |

Means sharing the same letters do not differs significantly at 0.05 probability level. T1: Control (NPK @ 23-80-50 kg ha$^{-1}$), T2: Foliar spray of boric acid (2 g L$^{-1}$) + NPK, T3: Foliar spray of boric acid (4 g L$^{-1}$) + NPK, T4: Foliar spray of boric acid (6 g L$^{-1}$), T5: Foliar spray of boric acid (8 g L$^{-1}$), T6: Foliar spray of boric acid (10 g L$^{-1}$)

**Table 4** Seed yield and yield components and of alfalfa (*Medicago sativa* L.) as influenced by different boron applications

| Treatments | Number of seeds pod$^{-1}$ | | Number of branches plant$^{-1}$ | | 1000-seed weight (g) | | Seed yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | 2015–16 | 2016–17 | 2015–16 | 2016–17 | 2015–16 | 2016–17 | 2015–16 | 2016–17 |
| T1 | 4.3d | 6.1d | 21.3c | 22.2 ns | 0.47e | 0.53d | 161.7e | 286.5f |
| T2 | 4.4c | 6.3c | 21.4b | 22.3 | 0.53d | 0.57d | 167.9d | 299.2e |
| T3 | 4.5bc | 6.4c | 21.5abc | 22.3 | 0.57c | 0.67c | 171.3c | 304.6d |
| T4 | 4.5bc | 6.6b | 21.5abc | 22.5 | 0.57bc | 0.70bc | 175.0b | 308.3c |
| T5 | 4.9a | 6.8a | 21.7a | 22.5 | 0.63a | 0.77a | 186.7a | 312.1a |
| T6 | 4.7b | 6.7b | 21.6ab | 22.4 | 0.60b | 0.72b | 176.1b | 310.1b |
| LSD value | 0.23 | 0.19 | 0.26 | - | 0.029 | 0.047 | 3.10 | 1.36 |

Means sharing the same letters do not differs significantly at 0.05 probability level. T1: Control (NPK @ 23-80-50 kg ha$^{-1}$), T2: Foliar spray of boric acid (2 g L$^{-1}$) + NPK, T3: Foliar spray of boric acid (4 g L$^{-1}$) + NPK, T4: Foliar spray of boric acid (6 g L$^{-1}$), T5: Foliar spray of boric acid (8 g L$^{-1}$), T6: Foliar spray of boric acid (10 g L$^{-1}$)

**Table 5** Economic analysis on per hectare basis for each treatment for alfalfa (*Medicago sativa* L.) seed yield as effected by boric acid foliar spray

| Treatments | Average Seed yield (kg ha$^{-1}$) | Increase yield over control (kg ha$^{-1}$) | Net return of increased yield over control (Rs.) | Additional cost (Rs. ha$^{-1}$) | Benefit cost ratio |
|---|---|---|---|---|---|
| T1: Control (NPK only) | 224.10 | – | | – | – |
| T2: FS-BA (2 g L$^{-1}$) + NPK | 233.50 | 9.40 | 9400.0 | 845.0 | 11.12 |
| T3: FS-BA (4 g L$^{-1}$) + NPK | 237.95 | 13.85 | 12465.0 | 1004.0 | 12.42 |
| T4 FS-BA (6 g L$^{-1}$) + NPK | 241.65 | 17.55 | 15795.0 | 1162.0 | 13.59 |
| T5: FS-BA (8 g L$^{-1}$) + NPK | 249.40 | 25.30 | 22770.0 | 1321.0 | 17.24 |
| T6:FS-BA (10 g L$^{-1}$) + NPK | 243.10 | 19.01 | 17100.0 | 1479.0 | 11.56 |

Means sharing the same letters do not differs significantly at $p \leq 0.05$ probability level. T1: Control (NPK @ 23-80-50 kg ha$^{-1}$), T2: Foliar spray of boric acid (2 g L$^{-1}$) + NPK, T3: Foliar spray of boric acid (4 g L$^{-1}$) + NPK, T4: Foliar spray of boric acid (6 g L$^{-1}$), T5: Foliar spray of boric acid (8 g L$^{-1}$), T6: Foliar spray of boric acid (10 g L$^{-1}$)

flowers and seeds. Ali et al. (2017) studied the effect of macro and micronutrients on growth and yield of cotton. It was reported that integrated use of macro and micronutrients markedly improved the plant growth and yield of cotton. Tahir et al. (2017) reported an increase in mungbean by zinc and iron application.

Dell et al. (2002) reported a significant effect of foliar B application on plant growth and seed yield Roy et al. (2006) suggested that the increase in pH reduced the availability of B, and the depressing effect was more noticeable in soils with a pH greater than 6. The impact on B fertilization on plant growth and yield was also reported by Lanyon and Griffith (1988). The results of our research are consistent with the opinion of Dordas (2006) who pointed out that B might have a significant impact on the yield, even when there are no deficiency symptoms of B in the vegetative parts of the plant, and when the concentration is in appropriate range. Yield components such as number of plants m$^{-2}$ had consistent values with no major deviation, and statistically significant differences among both years. In both years the number of branches plant$^{-1}$ had consistent values with no major deviations and significant differences. Economic analysis as shown in Table 5 showed that maximum benefit-cost ratio of 17.24 was obtained by the treatment where 8 g L$^{-1}$ boric acid foliar spray was carried out which was followed by treatment receiving 6 g L$^{-1}$ boric acid foliar spray. While, minimum benefit-cost ratio of 11.12 was found with treatment 2 g L$^{-1}$ boric acid foliar spray.

## CONCLUSION

Maximum forage yield of oat was found at N-$P_2P_5$ level of 100-56 kg ha$^{-1}$ whereas foliarly applied boric acid at a concentration of 8 g L$^{-1}$ produced the highest seed yield of alfalfa and economic returns.

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