Influence of Long-term Use of Organic and Inorganic Nutrients on HLB Disease of Wheat under Rice-Wheat Cropping Pattern

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ABSTRACT

Helminthosporium leaf blight (HLB) is one of the most destructive diseases of wheat in terai (plain) region of Nepal. This study was conducted to determine the effect of long-term application of various levels of nitrogen (N), phosphorus (P), potassium (K) and organic nutrients on HLB disease of wheat. The experiment was superimposed on long-term fertility experiment conducted in RCB design with three replications under rice-wheat cropping pattern at National wheat research program (NWRP), Bhairahawa, Nepal. The treatments include various combinations of nitrogen 100 kg ha^{-1}, phosphorus 0 and 60 kg ha^{-1}, and potash 0, 50 and 100 kg ha^{-1} with or without Sesbania (*Sesbania cannabina)* and farm yard manure (FYM). Area under disease progress curve (AUDPC) was calculated using the disease scores and yield parameters were recorded. Among the inorganic nutrients, long-term deficiency of potash in the field markedly enhances the HLB disease. Application of phosphorus in various doses increased the HLB severity in absence of potash. Regular application of at least potash 50 kg ha^{-1} in wheat noticeably reduced the HLB disease. Regular use of FYM 10 ton ha^{-1} for long-term considerably reduced the HLB disease but long-term use of Sesbania as green manure did not show any impact on HLB severity. Inclusion of potash in nutrients considerably increased the yield and thousand grain weight (TGW) of wheat. In long term, balanced use of inorganic and organic nutrients with special attention on regular inclusion of potash and FYM in the nutrient combinations is vital in suppression of HLB disease under rice-wheat cropping pattern.

Key words: AUDPC, FYM, Helminthosporium leaf blight, potassium

INTRODUCTION

Rice-wheat is the most important cropping pattern in terai (plain) areas of Nepal. Helminthosporium leaf blight (HLB) is one of the most destructive diseases of wheat in terai regions of Nepal. HLB generally occurs with complex infection of spot blotch (caused by *Cochliobolus sativus* (Ito & Kurib.) Drechsler ex. Dastur (anamorph: *Bipolaris sorokiniana*) and tan spot (caused by *Pyrenophora tritici repentis* (Died.) Drechsler (anamorph: *Drechslera tritici repentis*) in plain areas of Nepal (Sharma et al 2003). HLB prevails every year in the major wheat growing areas of the country due to the lack of durable and highly resistant cultivars, use of unbalanced fertilizers and poor management conditions. The losses due to the disease are remarkable in many regions of indo-gangetic plains including Nepal (Duveiller and Gilchrist 1993, Duveiller 2002). The yield losses due to HLB in farmers' fields of Nepal ranged from 20 to 25 percent (Saari 1997, Duveiller 2002**)**. The pathogens are weak hemi biotrophs, so cultural practices prominently influence the severity of disease (Ruckstuhl 1997, Naitao and Yousan 1997, Bocus and Shroyer 1998, Mathieoson et al 1990). Disease severity is increased under stressed plant growth conditions caused by low or unbalanced soil nutrients level, potash deficiency, poor management practices and high temperature and hot wind during the later stage of the crop (Ruckstuhl 1997, Naitao and Yousan 1997, Bhatta et al 1997, Sharma et al 2005). Resistant genotypes, seed treatment and foliar sprays with triazole fungicides are effective against the disease (Bhatta et al 1997, Naitao and Yousan 1997), however, except resistant genotypes; the other methods are not economically practicable for poor farmers of Nepal. Among several factors of cultural management, the role of plant nutrients is supreme in the suppression of HLB disease. Application of potash fertilizer reduces the HLB incidence significantly in both short- and long-term fertility conditions (Regmi et al 2002, Sharma et al 2005). Nepalese farmers use unbalanced and less amount of fertilizers in wheat, which results in lower yield due to the combined effect of nutrient deficiency and higher HLB disease.

Determination of role of various combinations of major inorganic and organic nutrients on HLB severity in long run could help to develop a durable and cost effective technology for HLB management. Therefore, this study was conducted to find out the effect of long-term use of various levels of nitrogen, phosphorus, potash, green manure and FYM on HLB disease of wheat.

MATERIALS AND METHODS

The experiment was superimposed on long-term fertility experiment under rice-wheat cropping system conducted at National Wheat Research Program, Bhairahawa in the year 2003-04. The long-term fertility experiment has been continuously conducted since 1988 with slight modification of treatments in 1995. The design was RCB with three replications. Genotype Nepal 297 was used in both the years. The final treatments after modification in 1995 include application of various combinations of nitrogen 100 kg ha^{-1}, phosphorus 0 and 60 kg ha^{-1}, and potash 0, 50 and 100 kg ha^{-1}, with or without Sesbania and farm yard manure (FYM). Sesbania was grown for 60 days and mixed on field before rice planting whereas, FYM 10 ton ha^{-1}, was applied to wheat only. Half of the nitrogen and full dose of phosphorus and potash was applied as basal and remaining half dose of nitrogen was applied 25 days after seeding as top dress. Ten main tillers in each plot were randomly selected and tagged prior to scoring disease intensity. Severity of disease was recorded by visually assessing the percent diseased leaf area on the flag leaf and penultimate leaf of tagged tillers. Three scores were recorded at 7 days intervals after the heading stage of the crop. Area under disease progress curve (AUDPC) was calculated following the formula given by Das et al (1992). Yield and thousand grain weight were recorded for analysis of yield features.

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance revealed that the treatments differed significantly ($P < 0.01$) for HLB AUDPC, yield and thousand-grain weight (TGW) in both years (Table 1). FYM had significant ($P < 0.01$) effect on suppression of HLB severity in both the years. Application of potash significantly ($P < 0.01$) reduced the HLB severity. Application of phosphorus in absence of potash significantly (P <

0.01) increased the disease severity. The effect of Sesbania before rice was insignificant for HLB AUDPC.

Effects of potash on HLB

Application of potash significantly reduced HLB severity on wheat under long-term rice-wheat cropping pattern (Table 1). Significantly lower disease in the treatments of NPK 100:60:100 and 100:60:50 kg ha^{-1} than in NPK 100:60:0 kg ha^{-1} signifies the impact of potash fertilizer on suppression of HLB disease under long-term fertility conditions (Figure 1). This result supports the outcomes of various similar previous studies (Sharma et al 2005, Regmi et al 2002**)**. Thin cell walls, weakened stalks and stems, smaller and shorter roots and accumulation of unused nitrogen caused by potassium deficiency enhance the disease infection (Anonymous 1998). Similarly, treatment 100:60:100 NPK kg ha^{-1} and 100:60:50 NPK kg ha^{-1} were statistically at par which suggest that the use of potash 50 kg ha^{-1} is sufficient to suppress the incidence of HLB under long-term fertility conditions (Figure 1).

Table 1. Combined mean HLB AUDPC on different treatments of long-term soil fertility experiment conducted at Bhairahawa during 2003 and 2004

SN	Treatments	Combined mean AUDPC of 2003 and 2004†
1	Sesbania before rice and NPK 100:60:100 kg ha^{-1}	483c
2	Sesbania before rice and NPK 100:60:0 kg ha^{-1}	1027a
3	Sesbania before rice and NPK 100:60:50 kg ha^{-1}	571c
4	NPK 100:60:0 kg ha^{-1}	1052a
5	NPK 100:60:50 kg ha^{-1}	516c
6	NPK 100:60:100 kg ha^{-1}	536c
7	FYM 10 t ha^{-1} in wheat and NPK 100:60:0 kg ha^{-1}	601c
8	FYM 10 t ha^{-1} in wheat and NPK 100:60:50 kg ha^{-1}	437c
9	FYM 10 t ha^{-1} in wheat and NPK 100:60:100 kg ha^{-1}	453c
10	FYM 10 t ha^{-1} in wheat and NPK 100:0:0 kg ha^{-1}	463c
11	Sesbania before rice and NPK 100:0:0 kg ha^{-1}	759b
12	NPK 100:50:0 kg ha^{-1}	1035a
13	NPK 100:100:0 kg ha^{-1}	1120a
14	NPK 100:0:0 kg ha^{-1}	840b

† *Means in a column followed by the same letter do not differ significantly at P = 0.05 according to Duncan's multiple range tests.*

Likewise, the insignificant differences for AUDPC among treatments Sesbania + 100:60:50, FYM + 100:60:50 and 100:60:50 indicate that application of balance dose of inorganic fertilizers is sufficient to reduce the HLB severity.

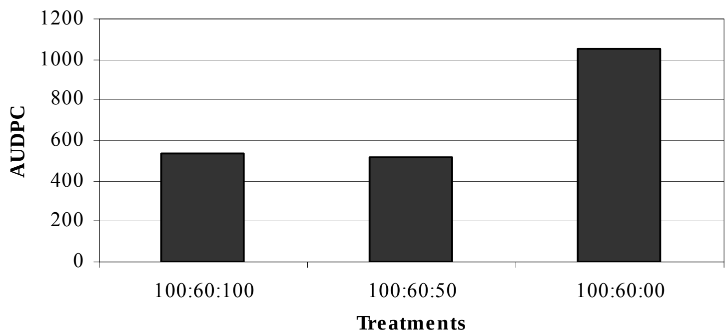

Figure 1. Effect of potash on HLB of wheat under long-term fertility (rice-wheat) conditions during 2003 and 2004.

Effects of phosphorus on HLB

The effect of phosphorus was adverse on HLB disease in absence of potash (Table 1). The incidence of HLB was high in treatments 100:100:0, 100:60:0 and 100:50:0 in both the years. Significantly higher AUDPC in treatments having only nitrogen and phosphorus than the treatments having NPK and only nitrogen indicate the adverse effect of phosphorus on HLB disease (Figure 2); however, the reasons behind this is not clear and need further investigation. The present results agree with the results of Gharti et al (2002). Similarly, significantly less HLB in the treatments Sesbania + NPK 100:0:0 and only NPK 100:0:0 kg ha^{-1} than the treatments NPK 100:50:0, 100:60:0 and 100:100:0 kg ha^{-1} suggests that for the suppression of HLB disease, application of nitrogen only should be prioritized over application of nitrogen and phosphorus. Likewise, statistically at par HLB incidences in treatments 100:50:0, 100:100:0 and 100:60:0 point out that the levels of phosphorus in the absence of potash haven't any effect on HLB severity. The present results support the previous findings that disease caused by *Cochliobolus sativus* is not affected by the addition of phosphorus (Bailey et al 1980).

Effects of FYM on HLB

The significant and lowest AUDPC in the treatments having FYM and FYM + potash proves the paramount role of these two nutrients on HLB suppression (Table 1). The least HLB disease in treatment having FYM 10 ton ha^{-1} + potash may be partially due to the reduction of primary inoculums present in the soil, because application of cow dung, urine and high levels of organic matter inhibit the conidial germination of *B. sorokiniana* (Akhtar et al 2006).

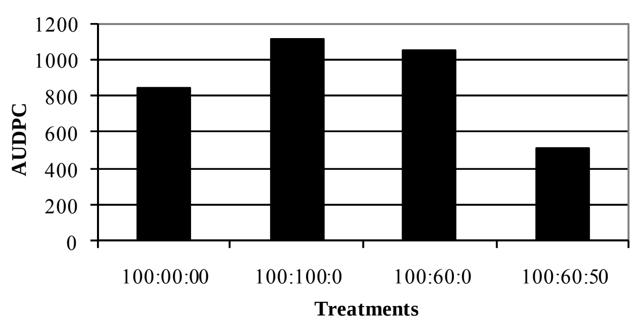

Figure 2. Effect of phosphorus on HLB of wheat under long-term fertility (rice-wheat) conditions during 2003 and 2004.

Likewise, the insignificant differences for HLB severity among 100:60:100 NPK kg ha^{-1}, 100:60:50 NPK kg ha^{-1} and FYM 10 ton ha^{-1} + 100:60:0 NPK kg ha^{-1} point out that application of FYM 10 ton ha^{-1} could suppress the HLB severity equal to the application of 50-100 kg potash ha^{-1}. These results agree with previous reports, which advocated that organic materials reduce disease incidence caused by many plant pathogenic bacteria, fungi and nematodes (Abawi and Widmer 2000, Conn and Lazarovits 2000, Lazarovits et al 2001).

Significantly less disease in FYM 10 t ha^{-1} + 100:0:0 NPK kg ha^{-1} than the treatments Sesbania + 100:0:0 NPK kg ha^{-1} and only 100:0:0 NPK ha^{-1} confirms the sole effect of FYM on HLB suppression (Figure 3). Similarly, significantly lower disease in FYM 10 ton ha^{-1} + 100:60:0 NPK ha^{-1} as compare to treatments Sesbania before rice + 100:60:0 NPK kg ha^{-1} and only 100:60:0 NPK kg ha^{-1} suggest the importance of FYM in HLB management under different nutrient combinations.

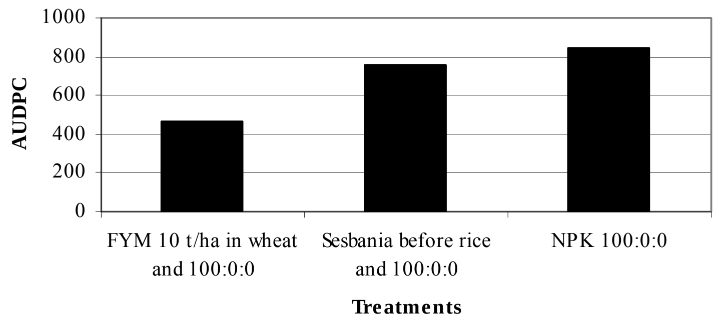

Figure 3. Effect of FYM on HLB of wheat under long-term fertility (R-W) conditions at Bhairahawa during 2003 and 2004.

Effects of Sesbania on HLB

Effect of long-term application of Sesbania before rice on HLB disease of wheat in any nutrient combinations was not seen (Figure 4). Sesbania hadn't any effect on HLB severity when it was added on the treatments containing all the three major elements such as 100:60:50 NPK kg ha^{-1} and 100:60:100 NPK kg ha^{-1}. Similarly, the addition of Sesbania on the treatment having nitrogen and phosphorus only (100:60:0 NPK kg ha^{-1}) also hadn't any influence on HLB severity. Present results do not support the previous findings of Nikonorova (1997) and Davis et al (1996), in which green manuring decreased the infection level of some soil borne diseases. However, based on present results and previous conclusions, it can be suggested that green manures may have less impact on foliar diseases than soil borne diseases.

Likewise, the higher and at par levels of AUDPC in treatments Sesbania + 100:0:0 NPK kg ha^{-1} and only 100:0:0 NPK kg ha^{-1} suggest the lack of influence of Sesbania on HLB severity when it is applied in the field having nitrogen only. The results also supports that application of higher amount of only nitrogen either in organic or inorganic form raised the severity of HLB because application of nitrogen level above 80 kg ha^{-1} induces the foliar disease incidence due to denser crop canopy (Wall et al 1990).

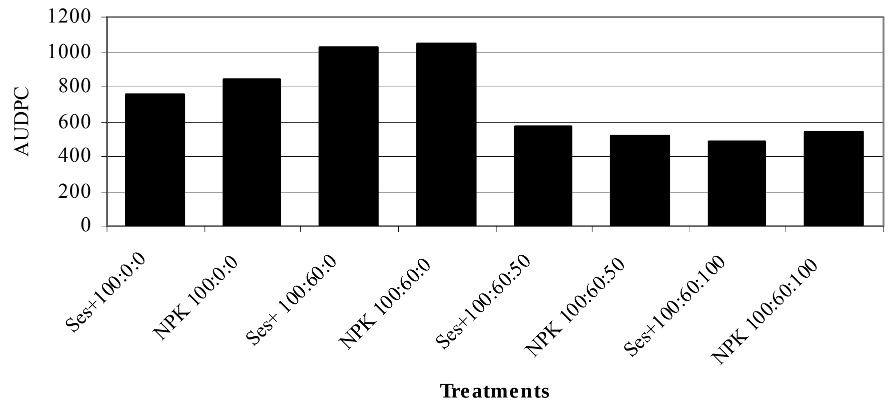

Figure 4. Effect of Sesbania on HLB of wheat in different nutrient combinations under long-term fertility (rice-wheat) conditions at Bhairahawa during 2003 and 2004.

Effects of various nutrients on yield of wheat

The yield of wheat was significantly different among the treatments (Table 2). However, the variation in yield was not solely due to the levels of HLB disease. The variations in yield were due to the combined effect of levels of nutrients and levels of HLB disease. Lower wheat yield and TGW with higher HLB AUDPC (Figure 5) confirms the previous reports which disclosed the negative correlations of HLB AUDPC with yield and TGW (Mahto 1999).

Treatments containing potash 50 kg ha^{-1} had significantly higher yield and TGW than the treatments that lack the potash. Treatments with only inorganic nitrogen and phosphorus had significantly lower yield and significantly higher AUDPC than treatments having inorganic nitrogen, phosphorus and potash. This result verifies the role of potash on wheat yield and HLB disease, which has been already explained by several previous workers (Sharma et al 2005, Regmi et al 2002, Gharti et al 2002).

Table 2. Combined mean yield and TGW on different treatments under long-term fertility condition at Bhairahawa during 2003 and 2004

SN	Treatments	Combined mean yield, kg ha^{-1} †	Combined mean TGW, g†
1	Sesbania before rice and NPK 100:60:100 kg ha^{-1}	2073ab	38.44a
2	Sesbania before rice and NPK 100:60:0 kg ha^{-1}	642c	21.77c
3	Sesbania before rice and NPK 100:60:50 kg ha^{-1}	2076ab	36.54ab
4	NPK 100:60:0 kg ha^{-1}	595c	20.98c
5	NPK 100:60:50 kg ha^{-1}	2421ab	39.36a
6	NPK 100:60:100 kg ha^{-1}	2102ab	35.21ab
7	FYM 10 t ha^{-1} in wheat and NPK 100:60:0 kg ha^{-1}	1870b	32.45b

8	FYM 10 t ha^{-1} in wheat and NPK 100:60:50 kg ha^{-1}	2601a	37.47ab
9	FYM 10 t ha^{-1} in wheat and NPK 100:60:100 kg ha^{-1}	2284ab	39.67a
10	FYM 10 t ha^{-1} in wheat and NPK 100:0:0 kg ha^{-1}	1903b	36.13ab
11	Sesbania before rice and NPK 100:0:0 kg ha^{-1}	250c	22.04c
12	NPK 100:50:0 kg ha^{-1}	640c	20.92c
13	NPK 100:100:0 kg ha^{-1}	481c	22.75c
14	NPK 100:0:0 kg ha^{-1}	342c	23.14c

† Means in a column followed by the same letter do not differ significantly at P = 0.05 according to Duncan's multiple range tests.

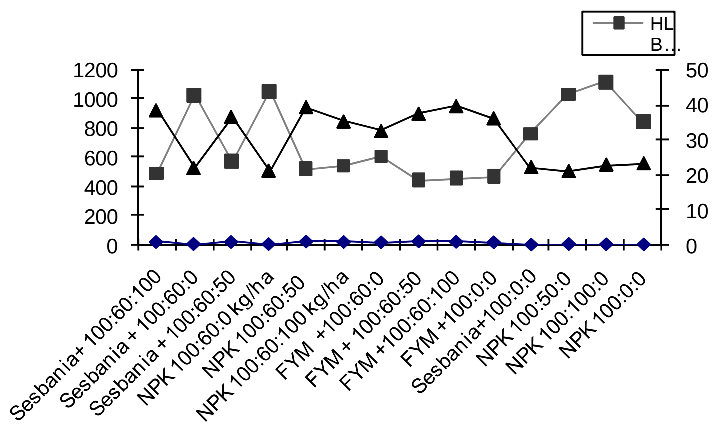

Figure 5. Relationship of HLB AUDPC with wheat yield and grain weight (TGW) in different nutrient combinations under long-term fertility (rice-wheat) conditions at Bhairahawa during 2003 and 2004.

CONCLUSION

In long-term, balanced use of inorganic and organic nutrients with special attention on regular inclusion of potash and FYM in the nutrient combinations is vital in suppression of HLB disease under rice-wheat cropping pattern. Long-term application of only nitrogen and phosphorus fertilizers boosts the HLB disease severity, where as application of 50 kg potash ha^{-1} in addition of nitrogen and phosphorus fertilizers considerably reduces the HLB disease severity. Similarly, long-term use of FYM effectively suppresses HLB disease in wheat, whereas long term applications of Sesbania couldn't suppress the intensity of HLB disease.

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