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Full Length Research Paper

Response of mustard and linseed to thermal power plant wastewater supplemented with nitrogen and phosphorus

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The effect of thermal power plant discharged waste water (TPPW) on growth, yield and quality of mustard (Brassica juncea L. cv. Alankar) and linseed (Linum usitatissimum L. cv. Neelam) was studied. TPPW increased growth characteristics, net photosynthetic rate, seed yield, oil content and oil yield of the two crops. In mustard, treatments TPPW N112P60 (112 kg N/ha + 60 kg P/ha), TPPW N112P30 (112 kg N/ha + 30 kg P/ha) and TPPW N90P60 (90 kg N/ha + 60 kg P/ha) were equally effective while in case of linseed lower levels of N and P with waste water proved beneficial. TPPW may be considered as an alternative of fresh water for irrigation purpose improving yield and quality of mustard and linseed.

Key words: Nitrogen, phosphorus, wastewater, mustard, linseed, seed yield, oil yield.

INTRODUCTION

Water is visibly so much that its value is accounted low as it is believed that the water resources are inex-haustible or at least more than sufficient for all our needs. However, the habitable land areas have only limited fresh water resources, and only about 0.5% is present either as ground water or as surface water in lakes, rivers, ponds and dams etc. (Cunningham and Saigo, 1995). Contr-arily, enormous amount of waste water is generated every year from urban population and industrialization and may cause environmental threat worldwide including India. Therefore, planned collection, treatment and disp-osal of the waste water are an important component in the protection of public health, surface soil and fresh water. The treatment of waste water is given low priority in India due to the financial constraints. Thus, alternative option appears to be reuse of waste water in agriculture for profitable crop production. This option may lessen the problem of water pollution and also serve as fertilizing components. The waste water contains nutrients of fer-tilizing value (Soumare et al., 2003) that enhances growth and yield of crop plants (Shah et al., 2004; Gupta et al., 2005; Javid et al., 2006). The present study was, there-fore, undertaken to assess the feasibility of exploiting the use of effluents generated by thermal power plant located at Aligarh, India for cultivation of mustard and linseed, the two commonly grown oil crops.

MATERIALS AND METHODS

Two pot experiments were conducted in naturally illuminated (photosynthetic active radiation (PAR) > 900 µ mol photons/m2/s; temperature 22oC) net house in the Department of Botany, Aligarh Muslim University, Aligarh, India (27º52' latitude, 78º51' longitude and 187.45m altitude). Healthy seeds of mustard (Brassica juncea L. Czern and Coss.) cv. Alankar and linseed (Linum usitatissimum L.) cv. Neelam were surface sterilized and sown on 28th October in 12" diameter earthen pots. Two plants per pot were maintained and harvested on 20th March. Pots were watered with ground water (GW) or thermal power plant waste (TPPW) and supplemented with six combinations of nitrogen (N) and phosphorus (P) viz., N68P30, N68P60¬¬, N90P30, N90P60, N112P30 and N112P60 applied bef-ore sowing. The digits with N and P denote fertilizer applied in kg/ha. The treatments were arranged in a randomized block design with five replicates for each treatment. Urea and single super phos-phate were used as the sources of nitrogen and phosphorus, respectively. Each pot was watered with 250 ml of TPPW or GW on alternate days. TPPW was collected from the leachate reservoir of Harduaganj thermal power plant, situated 14 km away from Aligarh, and tap water without any treatment was given as GW. TPPW was analyzed for various physico-chemical characteristics (Table 1) as per APHA (1989). The soil used for pots filling was low in N and P availability.

Crop growth and yield

Growth was studied at vegetative, flowering and fruiting stages in

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Table 1. Physico-chemical characteristics of ground water (GW) and wastewater (TPPW). All determinations in mg l^{-1} or as specified.

Characteristics	GW	TPPW
pH	8.3	8.7
EC (ds/m)	0.78	0.99
Mg	16.31	45.37
Ca	27.88	47.11
K	8	15
Na	21	47
HCO_3^-	61	89
CO_3^-	23	41
Cl^-	71.32	99.23
PO_4	0.09	0.97
NO_3-N	0.83	1.79
NH_3-N	3.78	7.21
SO_4	64	87

both crops. Net photosynthetic rate was measured in fully expanded leaves of mustard using LiCOR-6200 portable photosynthesis system with Ca = 0.33 m mol CO2 mol 1. All measurements were made in cloudless clear sky between 11:00 and 13:00 solar time. Leaf area was measured by leaf area meter (LA211, Cystronics, New Delhi). For dry weight, plants were dried in an oven at 80oC till constant weight. At harvest, yield attributes including seed yield and oil yield (oil content × seed yield divided by 100) were noted. The oil content of seeds in both crops was extracted with the help of soxhlet apparatus. Iodine value was calculated by iodine monochloride method, whereas acid and saponification values by Pearson (1981). All the data were analyzed statistically using the analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Photosynthesis in plants is a result of interaction among different factors like CO2 concentrations, ambient temperature, photon flux density, chlorophyll content, water and nutrients. In the present study, the plants that is, Mustard and Linseed grown under waste water recorded higher photosynthetic rate with TPPW N112P30 proving optimum (Figure. 1). These plants produced significantly greater leaf area than other treatments. Thus wastewater together with Nitrogen and Phosphorus @112 and 30 kg ha¬¬¬¬-1 respectively not only increased leaf area but also enhanced the photosynthetic rate. Nitrogen has a well established role in cell division, elongation, expansion and differentiation and also in biochemical reactions (Gardner et al., 1985), leading to increased growth and leaf area and thus allowing the plant to trap maximum solar energy and enhancing photosynthetic rate for biomass production. Similarly close correlation have also been found between crop yields and N application rates (Marshner, 2002). This may be due to the presence of essential elements like N, Mg and K in waste water.

While nitrogen and potassium are essential for photosynthesis through their direct involvement in increasing growth, magnesium is the centre of chlorophyll molecule and is also essential for various enzymatic reactions (Gardner et al., 1985) and Cl plays a role in stomatal regulation and its deficiency may result in reduction of leaf area and dry weight (Marshner., 2002).

Waste water, in general, proved beneficial for mustard as it significantly enhanced growth parameters like leaf area and leaf number which are important for photosynthesis. For linseed also, it proved effective recording higher values for plant fresh weight, plant dry weight and leaf number (Figures 1 - 2).

The beneficial effect of waste water on growth was due to the presence and regular supply of some of the essential nutrients with every irrigation, in addition to some of the essential nutrients present in soil, which ensured maximum growth and development. As waste water enhanced growth, this resulted in better formation and development of yield attributes including the seeds through optimum utilization of the nutrients available at the time of their requirement. In mustard, TPPW N112-P60, TPPW N112P30 and TPPW N90P60 proved equally effective, for seed yield. Thus in terms of fertilizer economy, TPPW N90P60 and TPPW N112P30 may be treated as optimum treatments while TPPW N112P60 may be accounted for luxury consumption as it has not enhanced the yield further. While in linseed waste water together with lower fertilizer dose proved as much efficient as ground water with higher fertilizer dose. In this way waste water can prove economical because of saving of some inorganic fertilizers as was confirmed by statistically equal values given by TPPW N68P60, TPPW N90P30, GW N90P60 and GW N112P30. Therefore, waste water plus lower fertilizer treatments may be treated as optimum (Figure 1 - 2) indicating lower requirement by linseed in contrast to mustard which may be attributed to the differences in their genetic makeup and the pattern of their growth. The deleterious effect of waste water when applied with higher fertilizer doses may be due to the nutrients crossing their critical limits, thereby proving excessive.

Oil yield in both the crops showed positive response to TPPW in comparison to GW. In mustard the same treatments that earlier proved superior for growth resulted in the production of maximum oil yield. In linseed waste water together with lower fertilizer doses proved more effective. Thus the treatment TPPW N68P60 proved best and it increased the oil yield by 50.54% over GW N68P30 which gave the lowest value. Contrary to growth and yield, the effect of waste water on oil content was not so distinct. In mustard TPPW N68P30 was optimum whereas in linseed TPPW N68P60 and GW N68P60 shared the maximum values. Thus, irrespective of irrigation water higher levels of nitrogen proved detrimental for oil. Similar findings about the nitrogen effect on oil have been shown by Satyavan et al. (1999) in mustard and Sarode et al.

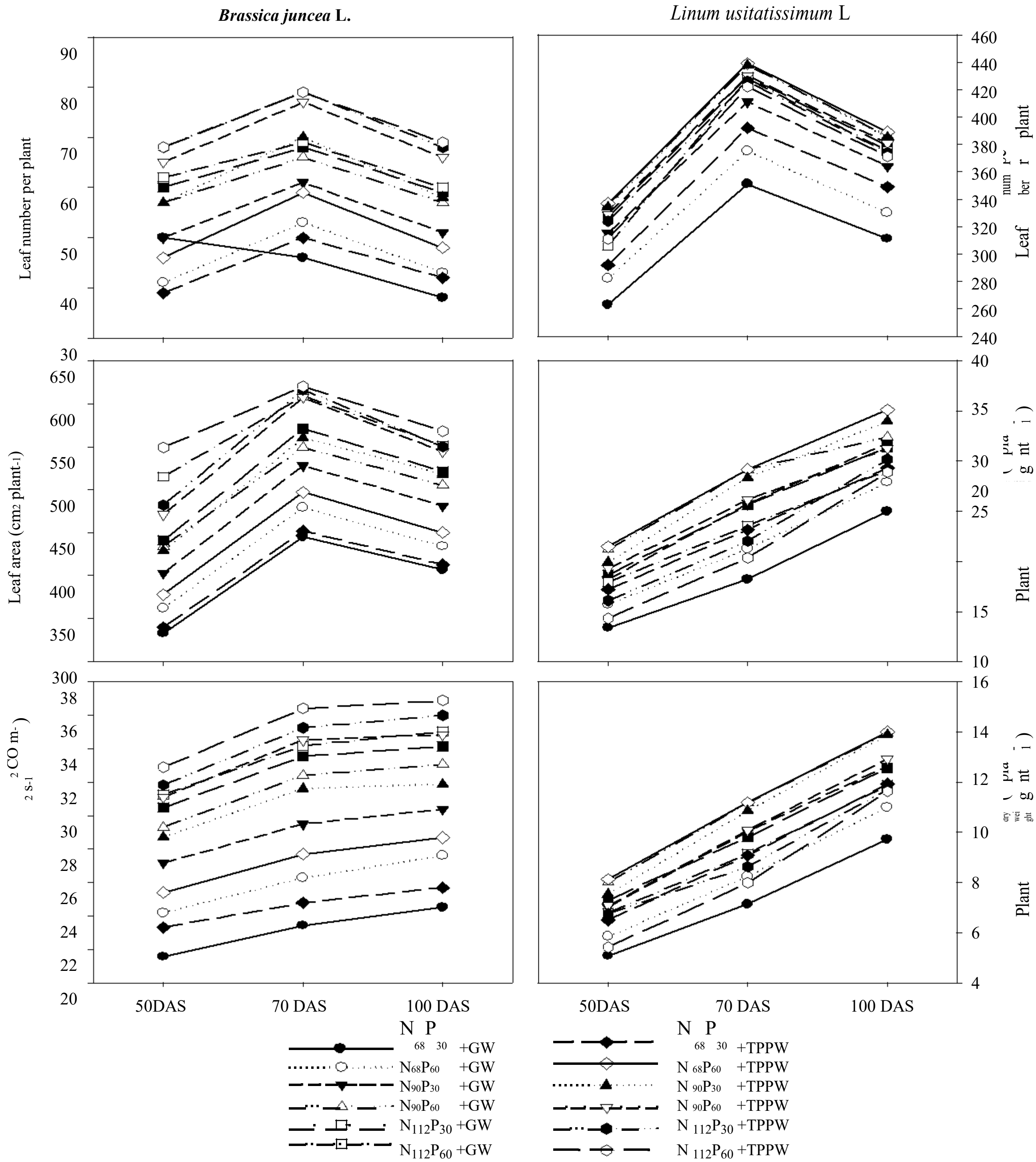

Figure 1. Effect of TPPW and GW along with N and P doses on growth and photosynthesis rate of mustard (*Brassica juncea* L) and linseed (*Linum usitatissimum* L)

(1997) in linseed. The apparent explanation for this adverse effect may be the preferential utilization of carbon in protein synthesis rather than in oil formation (Chourasia et al., 1992). However, the beneficial effect of applied nitrogen on seed yield in mustard was so spectacular that it out balanced the lower oil content in providing considerably enhanced oil yield.

In mustard iodine and saponification values were unaffected under waste water, therefore proving good as low iodine value denotes easy hydrogenation while high

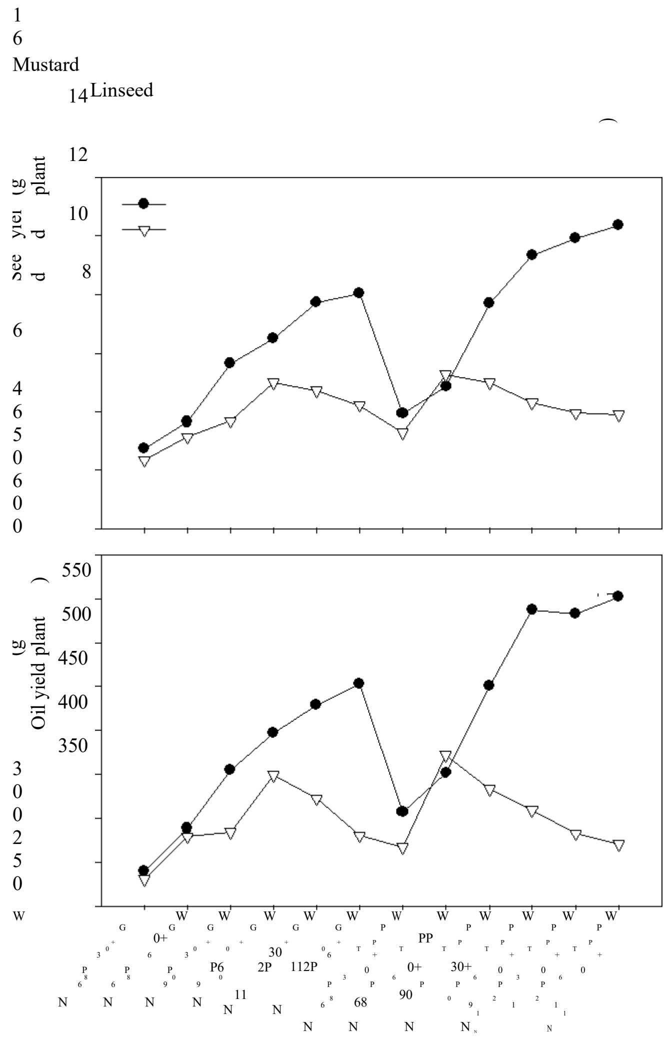

Figure 2. Effect of TPPW and GW along with N and P doses on seed yield and oil yield of mustard (Brassica juncea L.) and linseed (Linum usitatissimum L.)

saponification value is supposed to be good for digestibility. Waste water recorded lower acid value, which is considered as good for mustard oil quality (Figure 3). Waste water resulted in lower, iodine value in linseed compared to ground water, although high iodine value in linseed is considered good as far as its use in varnish industry is considered (Figure 3). Acid value and iodine value in mustard and linseed also decreased due to nitrogen fertilization. Other workers have also reported favorable effects of waste water on growth and yield (Shahalam et al., 1998; Darwish et al., 1999; Soumare et al., 2003; Shah et al., 2004; Gupta et al., 2005; Javid et al., 2006; Tabassum et al., 2007). However, reports on oil quality are not available in the literature.

It may, therefore be concluded that thermal power plant discharged waste water may be utilized profitably for growing mustard as well as linseed as its application not only increased the productivity of seeds but also oil. In addition, the use of TPPW for crop cultivation may also minimize the problem of its disposal.

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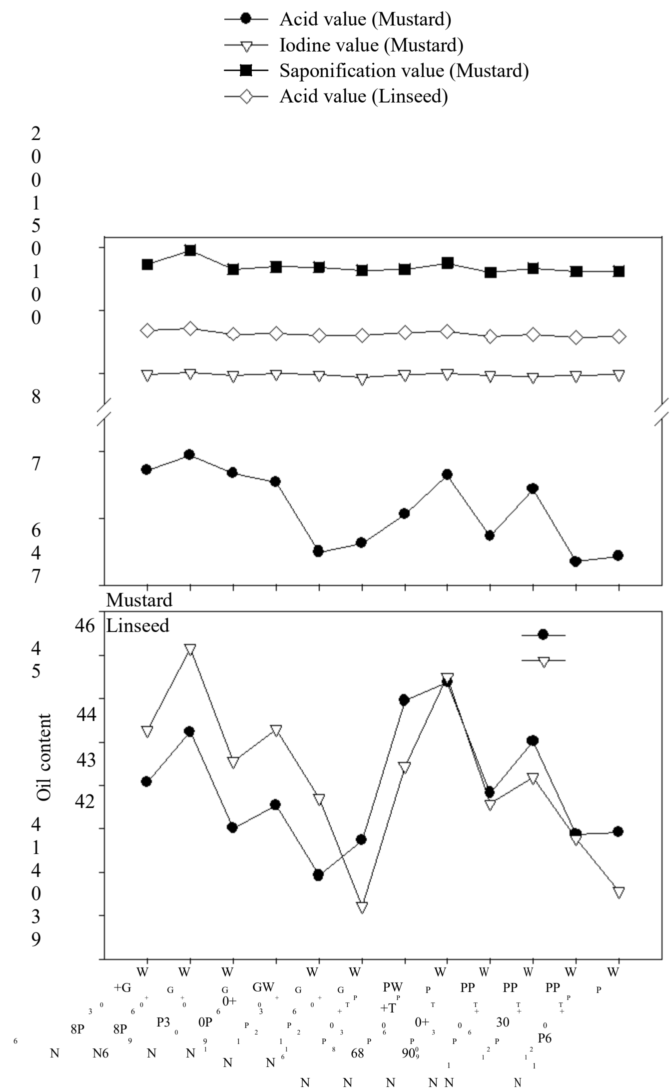

Figure 3. Effect of TPPW and GW along with N and P doses on acid, iodine, saponification values and oil content of mustard (Brassica juncea L.) and linseed (*Linum usitatissimum* L.).

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