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Effect of Integrated Nutrient Management on Productivity and Quality of Malt Barley (*Hordeum distichon* L.)

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ABSTRACT

Information on the effect of combined use of chemical fertilizers and organic manures in Malt Barley is limited. Also, the effect of incorporation of rice straw on growth and yield of Malt Barley and use of the fungus *Trichoderma viride* for acceleration of decomposition of rice straw has not been studied much. Therefore, this present investigation entitled, "Effect of integrated nutrient management on productivity and quality of malt barley (*Hordeum distichon* L.)" was carried out during the *rabi* season of 2017-18 at Amritsar, Punjab, India. Treatments comprised of T_1: Control, T_2: 100% Inorganic fertilizers (IF), T_3: 100% Farmyard manure (FYM), T_4: 100% Chopped rice straw (CRS), T_5: 100% CRS + *Trichoderma viride* (TV), T_6: 75% IF + 25% FYM, T_7: 50% IF + 50% FYM, T_8: 75% IF + 25% CRS, T_9: 50% IF + 50% CRS, T_{10}: 75% IF + 25% CRS + TV, T_{11}: 50% IF + 50% CRS + TV. Application of 100% NPK through inorganic fertilizers (IF) increased the ear length (7.92 cm), number of grains/ear (28.3), grain yield (44.6 q/ha) and straw yield (64.6 q/ha) and at par with 75% NPK through IF + 25% N through FYM. For a sustainable agriculture practice, up to 25% inorganic fertilizers can be substituted by FYM with less yield compensation. Furthermore, the soil pH, electrical conductivity and organic carbon content in the soil did not exhibit much affect in this single year trial. However, 100% NPK through IF significantly increased available N content over control and it was at par with 75% NPK through inorganic fertilizers + 25% N through FYM.

Key words: Farmyard manure, *Hordeum distichon*, Integrated nutrient management, Malt Barley, Rice straw, *Trichoderma viride*.

INTRODUCTION

Barley (*Hordeum distichon* L.) is an important cereal crop of the world. It is particularly grown in areas where there are less irrigation facilities and where soils are alkaline in nature. It is used as food for human beings, feed and fodder for livestock and also to process malt from the grains. It is preferred by the malt industry over other cereals as the glumes and hulls remain attached to the grain after threshing (Singh *et al.,* 2012).

From the time of green revolution farmers started using inorganic fertilizers for increasing their yield. Government also subsidized its rates which encouraged farmers to use it without consideration of its long term ill effects like deficiency of micronutrients, emission of greenhouse gases, leaching of fertilizers into the groundwater and polluting it, etc. Also, farmers are into the habit of using these inorganic fertilisers at more than the recommended dose because of subsidized rates and also because of the perception that it will increase the crop yield without consideration of the fact that their excess use will not increase the yield but will make the plant susceptible to insect-pest and disease attack. Hence, Government of India has recently decreased the Urea bag capacity to 45 kg from the earlier 50 kg to decrease its usage. The high analysis inorganic fertilisers contain lesser micronutrients. They also contain traces of heavy metals like Arsenic (As), Cadmium (Cd), Copper (Cu), Mercury (Hg) and Lead (Pb). These inorganic fertilisers thus create soil pollution by affecting the pH, organic matter content, texture and exchangeable sodium percentage (Singh *et al*., 1979). It has been revealed by long term experiments that sole application of inorganic fertilizers which supply only Nitrogen or Nitrogen and Phosphorus together without integrating organic manures has lead to degradation of soil quality (Ram *et al.,* 2015) and crop faces problem of micronutrients deficiency.

Information on the effect of combined use of chemical fertilizers and organic manures in Barley is limited. Also, the effect of incorporation of rice straw on growth and yield of Barley and use of the fungus *Trichoderma viride* for acceleration of decomposition of rice straw has not been studied much. Keeping in view the above considerations, a study of the effect of integrated nutrient management on productivity and quality of malt barley (*Hordeum distichon* L.) was conducted.

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MATERIALS AND METHODS

The experiment was conducted at Amritsar, Punjab during *rabi* season of 2017-2018. Amritsar is located at 31°-38′ North latitude and 74°-52′ East longitude and at an altitude of 236

m above mean-sea level. During the experimental trial, maximum temperature ranged between 19.6°C and 35.1°C and minimum temperature ranged between 3.2°C and 20.9°C during the crop growth period. The soil of the experimental field was sandy loam in texture with saline pH (8.3) and electrical conductivity (0.3), medium in organic carbon (0.48%), low in available N (175.6 kg/ha) and medium in available P (20.8 kg/ha) and available K (251.2 kg/ha). The nutrient composition of Farmyard manure used was analyzed and found to be 0.86% N, 0.45% P_20_5 and 0.97% K_2O on dry weight basis. Similarly the nutrient composition of rice straw used was analyzed and found to be 0.76% N, 0.20% P_20_5 and 1.23% K_2O on dry weight basis.

The malt barley variety DWRUB-52 was sown at 22.5 cm spacing on November 6, 2017. The experiment was laid out in Randomised Block Design with 11 treatments and replicated three times. Treatments comprised of T_1: Control, T_2: 100% Inorganic fertilizers (IF), T_3: 100% Farmyard manure (FYM), T_4: 100% Chopped rice straw (CRS), T_5: 100% CRS + *Trichoderma viride* (TV), T_6: 75% IF + 25% FYM , T_7: 50% IF + 50% FYM , T_8: 75% IF + 25% CRS, T_9: 50% IF + 50% CRS, T_{10}: 75% IF + 25% CRS + TV, T_{11}: 50% IF + 50% CRS + TV. The gross plot size was 4.5 m × 4.5 m and the net plot size was 3.6 m × 3.6 m Nitrogen was applied in the form of Urea just before pre-sowing irrigation. Phosphorus was applied as Single superphosphate whereas Potassium was applied as Muriate of Potash and these were mixed with the seeds at the time of sowing. Farmyard manure and Rice straw were applied in the respective plots on dry weight basis. The amount of Farmyard manure added was 7.27 t/ha whereas chopped rice straw (CRS) was 8.22 t/ha. The rice straw obtained was chopped before its incorporation. Incorporation of FYM and CRS in the respective plots was done 15 days before sowing by 3 ploughings using cultivator. The CRS was treated with *Trichoderma viride* culture and then applied in the respective plots.

Five plants were selected from each plot and used for the calculation of plant height, dry matter accumulation (DMA) and Leaf Area Index (LAI). Total number of effective tillers/ metre row length (mrl) were counted from two representative sites before harvesting the crop from each plot. Ten representative ears were selected randomly from each plot to record their length and were threshed to count and represent number of grains/ ear. Observation of grain yield and straw yield from net plot area of 7.29 m^2 from each plot was recorded. The crop was manually threshed plot wise and then its grain yield was recorded. Nitrogen content in grains was determined by Kjeldahl's method. The percentage of crude protein in grain was calculated using the formula:-

$$\text{Protein content (\%)} = \text{N content in grain (\%)} \times 6.25$$

The N uptake by grains was calculated as under:

$$\text{N uptake by grain (kg/ha)} = \frac{\text{N content in grain (\%)} \times \text{grain yield (kg/ha)}}{100}$$

Malting of Barley grains was carried out to obtain the malt yield. Properly cleaned, 250g of sample of barley grains was steeped in water at 15°C in an incubator for a period of 60 hours. The steeped samples taken in a muslin cloth were placed in a wooden box with wire mesh bottom for germination in an incubator at 15°C and relative humidity of more than 90 per cent. They were allowed to germinate for a period of 5 days. Then the green malt was kilned in an oven at 45°C for the first 20 hours and then at 85°C for 4 hours. Roots from the kilned malt were removed. Weight of malt and roots was recorded separately to calculate malt recovery (%).

$$\text{Malt recovery (\%)} = \frac{\text{Malt weight}}{\text{sample weight}} \times 100$$

Kernel plumpness of barley grains was estimated by the following method. 250g of grains were taken and sieved through 1.9 × 0.24 cm sieve. The grains which remain on the sieve and do not pass through it are collected, weighed and expressed as kernel plumpness (% weight basis)

$$\text{Kernel plumpness (\%)} = \frac{\text{Weight of grains retained on sieve}}{\text{Weight of grains before sieving}} \times 100$$

The experimental soil was analyzed for post-harvest observations. Representative soil samples (0-15 cm depth) from each experimental plot were collected, air dried in shade and processed to pass through 2mm sieve and preserved for analysis. pH of soil sample was estimated by pH digital meter and Electrical conductivity of soil sample was estimated by EC digital meter. Organic carbon content of the soil was determined by Walkley and Black's wet combustion method. The available nitrogen in the soil was estimated by alkaline permanganate method.

Statistical analysis

Statistical analysis of the data recorded was done as per Randomized Block Design, using online OPSTAT software developed by CCS Haryana Agricultural University, Hisar, Haryana. Critical difference (CD) values at 5% level of probability were obtained to examine differences among the treatments.

RESULTS AND DISCUSSION

Crop growth

The plant height was significantly affected by various integrated nutrient practices and ranged between 68.6 to 103.3 cm. Among the treatment combination, 100% NPK-IF recorded higher plant height (103.3 cm) at par with 75% IF + 25% FYM (100.1 cm) while lower plant height was with control (67.6 cm) at par with 100% N-CRS (70.9 cm) and 100% N-CRS-TV (72.7 cm). More plant height was recorded when inorganic fertilizers were applied either in full or in combination with FYM (Ram and Mir 2006) over Control. It might be due to better and timely availability of nutrients.

At 120 DAS, maximum LAI was recorded in 100% NPK-IF (2.63) which was at par with 75% NPK-IF + 25% N-FYM (2.5) but significantly higher than other treatments (Table 1). Minimum LAI was recorded in Control (1.32) at par with 100% N-CRS (1.43) and 100% N-CRS-TV (1.49). 100% N- FYM significantly increased LAI over Control. It can be ascribed to the fact that FYM application increased the organic carbon and available nitrogen content of soil which led to higher leaf area (Walia *et al.,* 2010).

The treatment 100% NPK-IF (112.4 q/ha) being at par with 75% NPK-IF + 25% N-FYM (109.6 q/ha), recorded significantly higher Dry matter accumulation (DMA) than other treatments (Table 1). Minimum DMA was recorded in Control (54.6 q/ha) at par with 100% N-CRS (58.5 q/ha). Higher leaf area in 100% NPK-IF may be the reason for higher DMA in the 100% NPK-IF over others as an increase in leaf area resulted in better interception and utilization of radiant energy which led to higher photosynthesis and ultimately more DMA.

Yield attributes and Yield

Among different treatments, the highest number of effective tillers /metre row length were obtained in 100% NPK-IF which was at par with the treatments 75% NPK-IF + 25% N-FYM, 50% NPK-IF + 50% N-FYM, 75% NPK-IF + 25% N-CRS and 75% NPK-IF + 25% N-CRS + TV but significantly higher than rest of the treatments (Table 2). Minimum number of effective tillers were obtained in Control (71.5) at par with 100% N-CRS (72.0) and 100% N-CRS-TV (72.7). More number of effective tillers were observed where inorganic fertilizers were applied either in full or in combination with FYM over other treatments (Table 2). It might be due to adequate supply of assimilates at the reproductive stage which led to increased number of effective tillers/ metre row length (Vidyadharan 2008).

Maximum ear length of 7.92 cm was observed in 100% NPK-IF which was at par with 75% NPK-IF + 25% N-FYM but recorded significantly longer ears than other treatments. It might be due to better translocation of assimilates to the sink due to timely availability of nutrients by the inorganic fertilizers (Singh and Chauhan 2016). Significantly longer ears were produced in 100% N-FYM over 100% N-CRS and 100% N-CRS + *Trichoderma viride*. Similar trend was observed in number of grains/ ear.

Application of 100% N-FYM recorded significantly higher no. of grains/ ear over Control (Table 2). It might be due to the beneficial effect of FYM on crop growth which had a positive influence on the no. of grains/ ear.

The highest grain yield (44.6 q/ha) was obtained in 100% NPK-IF which was at par with 75% NPK-IF + 25% N-FYM but significantly higher than other treatments. The magnitude of increase in grain yield in 100% NPK-IF and 75% NPK-IF + 25% N-FYM over Control was 110.4% and 98.6%, respectively. Beneficial effect of integrated application of inorganic fertilizers and FYM on plant height, DMA and LAI resulted in higher grain yield (Chavarekar *et al.,* 2013). Similar trend was observed in straw yield of malt barley. The increase in straw yield in the 100% NPK-IF and 75% NPK-IF + 25% N-FYM over Control was 94.6% and 88%, respectively. The increase in straw yield in 100% NPK-IF over Control is possibly due to beneficial effect of inorganic fertilizers on growth parameters and yield attributes (Shaktawat and Shekhawat 2010).

Maximum malt yield of 36.2 q/ha was obtained in 100% NPK-IF which was at par with 75% NPK-IFI + 25% N-FYM and 50% NPK-IF + 50% N-FYM but significantly higher than other treatments. The possible reason for higher malt yield in 100% NPK-IF over other treatments (Singh *et al.,* 2012) is its higher grain yield. Various nutrient management treatments significantly influenced the malt recovery from the Control (83.4%) while the least malt recovery was recorded in 100% NPK-IF (81.3%). The malt recovery obtained by the treatment 100% NPK-IF was significantly lower from the malt recovery obtained by the treatments Control, 100% N-FYM, 100% N-CRS + TV and 100% N-CRS. The treatment 100% N through Farmyard manure recorded lower malt recovery than the treatments 100% N-CRS and 100% N-CRS + TV. The supply of readily available nutrients through inorganic fertilizers led to better translocation of photosynthates to the grain at the grain filling stage. This increased the nitrogen content in the grains. Since nitrogen is directly involved in protein synthesis, hence, higher protein content in the grains was recorded. This ultimately caused lower malt recovery in the treatment 100% NPK-IF. This is in conformity with the findings of Verma *et al.,* (2003), Singh *et al.,* (2012) and Chavarekar *et al.,* (2013).

Quality

The higher N content of grains was recorded in 100% NPK-IF (1.62%) which was at par with 75% NPK-IF + 25% N-FYM (1.59%) but significantly higher than other treatments. The treatment 100% N-FYM recorded significantly higher N content than 100% N-CRS and 100% N-CRS + *Trichoderma viride*. Minimum N content was recorded in Control (1.24%). Similar findings were documented by Farhani *et al.,* (2011). Significantly higher protein content was recorded by the application of 100% NPK-IF (T_2) over Control (T_1). It is possibly due to higher nitrogen content of grains in 100% NPK-IF and since nitrogen is directly involved in protein synthesis, so higher protein content is recorded. Grant *et al.,* (1991) also reported an increase in protein content of grains in all cultivars of barley by the application of Nitrogenous fertilizers over Control.

Kernel plumpness was not significantly affected by different nutrient management treatments. The highest value was recorded in Control (82.4%) whereas the lowest value was recorded in 100% NPK-IF (80.9%). The decrease in kernel plumpness in 100% NPK-IF over other treatments may be due to increased availability of nutrients in this treatment, the number of tillers per plant and number of spikes per plant increased, which increased the number of grains to a level which could not be supported during the grain filling stage (Baethgen *et al.,* 1995).

Table 1: Effect of integrated nutrient management on growth of Barley.

Treatments	Plant height at harvest (cm)	Dry matter accumulation at harvest (q/ha)	Leaf area index at 120 DAS	No. of Effective tillers/ mrl	Ear length (cm)	No. of Grains/ Ear
Control	68.6	54.6	1.32	71.5	4.54	19.2
100% NPK through inorganic fertilizers (IF)	103.3	112.4	2.63	95.7	7.92	28.3
100% N through Farmyard manure (FYM)	82.1	72.5	1.76	84.0	5.59	22.6
100% N through Chopped rice straw (CRS)	70.9	58.5	1.43	72.0	4.79	19.6
100% N through CRS + *Trichoderma viride* (TV)	72.7	63.4	1.49	72.7	4.85	20.0
75% NPK through IF + 25% N through FYM	100.1	109.6	2.5	95.0	7.77	27.9
50% NPK through IF + 50% N through FYM	93.9	103.3	2.37	93.3	7.17	25.7
75% NPK through IF + 25% N through CRS	91.6	85.5	2.06	87.5	6.32	24.7
50% NPK through IF + 50% N through CRS	88.2	76.7	1.84	85.3	5.75	23.0
75% NPK through IF + 25% N through CRS + TV	92.7	90.1	2.12	89.0	6.46	25.1
50% NPK through IF + 50% CRS + TV	89.3	81.3	1.95	86.2	5.91	24.3
C.D. @ 5%	9.26	8.94	0.24	8.97	0.69	2.56

Table 2: Effect of integrated nutrient management on Barley productivity, quality and Nutrient uptake.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Malt recovery (%)	Malt yield (q/ha)	Grain N content (%)	Grain N uptake (Kg/ha)	Grain Protein content (%)	Kernel plumpness (% weight basis)*
Control	21.2	33.2	83.4	17.7	1.24	26.2	7.74	82.4
100% NPK through inorganic fertilizers (IF)	44.6	64.6	81.3	36.2	1.62	72.5	10.14	80.9
100% N through Farmyard manure (FYM)	29.7	45.6	82.7	24.6	1.36	40.7	8.49	81.9
100% N through Chopped rice straw (CRS)	21.9	36.2	83.3	18.3	1.27	27.9	7.92	82.3
100% N through CRS + *Trichoderma viride* (TV)	23.6	37.9	83.1	19.7	1.28	30.7	8.03	82.2
75% NPK through IF + 25% N through FYM	42.1	62.4	81.6	34.4	1.59	67.3	9.96	80.9
50% NPK through IF + 50% N through FYM	40.1	58.6	81.7	32.7	1.54	61.8	9.65	81.1
75% NPK through IF + 25% N through CRS	34.1	51.4	82.2	28.0	1.45	49.4	9.03	81.5
50% NPK through IF + 50% N through CRS	31.2	46.5	82.6	25.8	1.38	43.3	8.63	81.8
75% NPK through IF + 25% N through CRS + TV	35.6	52.7	82.0	29.3	1.46	52.4	9.14	81.4
50% NPK through IF + 50% CRS + TV	33.7	49.7	82.4	27.7	1.42	47.8	8.85	81.7
C.D. @ 5%	4.27	5.78	1.33	3.60	0.07	7.79	0.44	NS

* weight of grains retained on 1.9 x 0.24 cm sieve.

Table 3: Effect of integrated nutrient management on soil properties.

Treatments	pH	EC (dS m^{-1})	Organic Carbon (%)	Available N (kg/ha)
Control	8.29	0.301	0.468	149.7
100% NPK through inorganic fertilizers (IF)	8.27	0.303	0.485	177.0
100% N through Farmyard manure (FYM)	8.15	0.287	0.504	159.6
100% N through Chopped rice straw (CRS)	8.19	0.292	0.491	151.8
100% N through CRS + *Trichoderma viride* (TV)	8.20	0.291	0.493	156.0
75% NPK through IF + 25% N through FYM	8.22	0.298	0.494	171.1
50% NPK through IF + 50% N through FYM	8.19	0.295	0.497	169.5
75% NPK through IF + 25% N through CRS	8.25	0.299	0.485	163.9
50% NPK through IF + 50% N through CRS	8.24	0.297	0.488	160.8
75% NPK through IF + 25% N through CRS + TV	8.25	0.298	0.487	165.0
50% NPK through IF + 50% CRS + TV	8.23	0.297	0.491	161.2
C.D. @ 5%	NS	NS	NS	7.38

Nutrient uptake

The highest grain N uptake was obtained in 100% NPK-IF (72.5 kg/ha) which was at par with 75% NPK-IF + 25% N-FYM but significantly higher than the other treatments. 100% N-FYM recorded significantly higher grain N uptake over 100% N-CRS and 100% N-CRS + *Trichoderma viride*. Minimum grain N uptake was recorded in Control (26.2 kg/ha). There was a significant increase in grain N uptake by the application of 100% NPK-IF (T_2) over Control (T_1). This increase in grain N uptake was due to higher N content in the grains and grain yield in this treatment over Control.

Soil chemical properties

There was no significant difference in soil pH due to various nutrient management treatments. The highest pH was recorded in Control (8.29) whereas the lowest pH was recorded in 100% N-FYM (8.15). Various nutrient management treatments did not significantly affect soil Electrical conductivity (EC). The range of soil EC in different treatments varied from 0.287 to 0.303 dS/m. Similarly, there was no significant difference in soil Organic carbon (OC) values in different nutrient management treatments. The range of soil OC value in different treatments varied from 0.468% to 0.504%. The available N content of the soil was significantly affected by various nutrient management treatments. The highest content of available N was observed in 100% NPK-IF (177 kg/ha), whereas the lowest content was observed in Control (149.7 kg/ha). The available N content in soil of 100% NPK-IF was at par with 75% NPK-IF + 25% N-FYM but significantly higher than other treatments. Amongst the organic nutrient management treatments, the value of the treatment 100% N through FYM was significantly higher than 100% N-CRS and 100% N-CRS + TV. The magnitude of increase in available N in 100% NPK-IF, 100% N-FYM and 75% IF + 25% FYM over Control was 18.2%, 6.6% and 14.3%, respectively. The available N content in soil of 100% N-FYM was higher than Control. The possible reason for this increase is the mineralisation of FYM due to which nitrogen was released in the soil, ultimately increasing the available N content of the soil. Thamaraiselvi *et al.,* (2012) also reported an increase in available N content of the soil by the application of FYM.

CONCLUSION

It may be concluded that application of 100% NPK-IF produced highest grain and straw yield which remained at par with 75% NPK-IF + 25% N-FYM. These results indicate that for a sustainable agriculture practice, up to 25% inorganic fertilizers can be substituted by FYM with less yield compensation.

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