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Influence of growth, yield attributes and yield of barley (*Hordeum vulgare*) by various nutrient management practices

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Abstract
A field study was conducted during *rabi* season of 2023-24 at Research Farm, School of Agriculture, Suresh Gyan Vihar University Jaipur, to study the "Effect of Nutrient Management Practices on Growth, Yield and Quality in Barley (*Hordeum vulgare*)". The experiment was laid out in randomized block design with three replications. The experiment was consisting nine treatments *viz*., control, RDF 100%, FYM (10 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage, Vermicompost (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage, 75% RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage, 75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage, 50% RDF + FYM (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage, 50% RDF + Vermicompost (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage and two Vermiwash spray @ 5% (at tillering stage & jointing stage) with three replications. The barely variety used for study was DWRB-137.
The experimental results showed that application of 75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage produced significantly higher plant height and dry matter accumulation at 45, 90 DAS and harvest, number of effective tillers $plant^{-1}$, number of grains ear^{-1}, ear length, test weight, grain, straw and biological yield over rest of the treatments but it was remained at par with the application of % RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage.

Keywords: Barley, FYM, Vermiwash, vermicompost, yield

Introduction

Barley is one of the most important crops for food, feed, malt and income generation for many smallholder farmers in the highlands of Ethiopia (Bayeh and Berhane, 2011) [5]. Despite its importance and many useful characteristics, there are several factors affecting its production (Melle *et al*., 2015) [22]. Due to high nutritional and medicinal quality, it is used in Ayurvedic medicines and is used to cure fever, cold, asthma, skin diseases, sore throat, digestive system and to control the cholesterol level of blood (Kumar *et al*., 2020) [19].
The most important factors that reduce yield of barley are poor soil fertility, water logging, drought, frost, soil acidity (low soil pH), diseases and insects, poor crop management practices, limited availability of improved varieties and weed competition (Assefa *et al*., 2017) [3]. To maximize yield and quality of barley, it has been shown that nutrient management practices should be adjusted according to anticipated availability of nutrients to the crop (Edney *et al*., 2014) [9]. Integrated soil fertility management (ISFM) can give benefit to production and livelihood of farmers; the resilience of cropping system to climate change impacts and mitigation of greenhouse gas from fertilizers and soil (Melle *et al*., 2015) [22]. Before sowing, the residues of nitrogen in soil should be maintained to minimize nitrogen application, to increase the malting quality and yield (Malik, 2017) [21].
Organic agriculture is a production system which relies on ecosystem management and ecological processes rather than on the external flow of agricultural inputs (Foissy *et al*., 2013) [11]. Jarvan *et al*. (2017) [15] reported that FYM is one of the more valuable organic fertilizers maintaining soil fertility in the systems of alternative agriculture. Maintenance and improvement

of soil potential fertility are closely related to the maintenance of soil organic matter and organic carbon balance (Baksiene *et al*., 2014) [4]. Fertilizers are concentrated sources of essential nutrients in a form that is readily available for plant uptake (Fairhurst, 2012) [10]. Abedi *et al*. (2010) [1] inorganic fertilizers are fertilizers, either natural or manufactured, containing nutrients essential for the normal growth and development of plants.

Integrated plant nutrient management is the application of inorganic fertilizer in combination with organic fertilizer to maintain soil fertility and to balance nutrient supply in order to boost up the crop yield per unit. Emerging evidence indicated that integrated nutrient management involving the judicious use of organic and inorganic resources is a feasible approach to overcome soil fertility constraints (Abedi *et al*., 2010) [1]. Kaur *et al*. (2008) [17] stated that a judicious combination of organic amendments and inorganic fertilizers is widely recognized strategy of integrated nutrient management to sustain agronomic productivity and improve soil fertility.

Materials and Methods

The experiment was laid out at Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan) which is situated at an altitude of 432 metre above mean sea level with 26º48’35” N latitude and 75º51’44” E longitude. This region falls under agro-climatic zone IIIa (Semi-Arid Eastern Plain Zone) of Rajasthan. The average annual rainfall of this tract ranges between 400-500 mm, most of which is contributed by the south-west monsoon during July and August. There is hardly any rain during winter months. The maximum and minimum temperatures during the crop season ranged between 30.2°C to 35.2°C and 9.9°C to 23.0°C, respectively. A total of 365.5 mm rainfall was recorded during the crop season.

The sandy loam texture of the experimental field soil had a pH of 7.70, which was slightly alkaline in reaction, very low amount of organic carbon (0.42%), very low in available nitrogen (135.66 kg ha^{-1}), medium in available phosphorus (20.93 kg ha^{-1}) and high in available potassium (234.23 kg ha^{-1}) and low in available sulphur (16.35 kg ha^{-1}). On November 18, 2023, the crop was sown with variety of DWRB-137. There were three replications and nine treatments *viz*., control, RDF 100%, FYM (10 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, vermicompost (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 75% RDF + FYM (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 75% RDF + vermicompost (1.25 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 50% RDF + FYM (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 50% RDF + vermicompost (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage and two vermiwash spray @ 5% (at tillering stage & jointing stage), which were laid out in randomized block design.

Five plants were selected randomly from each plot and tagged permanently. Height of these five plants was measured at 45, 90 DAS and at harvest from the base of the plant to the top of the flag lead by metre scale and their mean was expressed as plant height (cm). Dry matter accumulation (g plant^{-1}) was recorded at 45, 90 DAS and at harvest and plants were uprooted randomly from sample rows of each plot. After removal of the root portion, the samples were first air-dried for some days and finally dried in an electric oven at 68 °C till a constant weight was achieved. The weight was recorded and expressed as g plant^{-1}. The number of tillers (m^{-1} row length) at harvest was counted on five randomly selected place in each plot and then average was recorded as number of tillers as m^{-1} row length. The number of effective tillers (m^{-1} row length) of five plants randomly selected from each plot was counted at harvest and average number of effective tillers m^{-1} row length was worked out. Number of spikelets ear^{-1} was recorded at harvest by counting the spikelets of the five randomly collected ear from each plot and the average value was estimated. The length of ear of each plant was measured from the five selected (tagged) plants and their mean was taken and expressed in cm. Number of grains ear^{-1} was counted from the five selected (tagged) plant’s spike and their mean was taken. Samples were drawn randomly from produce of each plot and one thousand seeds were counted from each sample and weighed to record test weight. After threshing and winnowing of the seeds from each net plot were weighed in kg plot^{-1} and converted in kg ha^{-1} for grain yield. Straw yield was obtained by subtracting the grain yield (kg ha^{-1}) from biological yield (kg ha^{-1}). The harvest index was calculated by using following formula and expressed as percentage (Singh and Stoskoff, 1971) [26].

$$\text{HI (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Experimental data recorded in various parameters were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950).

Results and Discussion

Growth parameters

The highest plant height and dry matter accumulation at 45, 90 DAS and at harvest was recorded with application of 75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage which was significantly higher rest of the treatments but remained at par with the application of 75% RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage (Table 1). Increase in level of nitrogen significantly increased the plant height, dry matter accumulation at 45, 90 DAS and at harvest and number of total tillers plant^{-1} at harvest. The significant improvement in various growth parameters might be attributed to the fact that nitrogen helps in maintaining higher auxin level which might have resulted in better plant height and dry matter accumulation at 45, 90 DAS and at harvest. This might have resulted into better interception, absorption and utilization of radiant energy, leading to higher photosynthetic rate and finally more accumulation of fresh as well as dry matter by the plants. The increases in growth parameters with increasing levels of nitrogen have also been reported by Dekhane *et al*. (2017) [8], Kumar *et al*. (2020) [20], Patel *et al*. (2021) [24] and Kumar *et al*. (2022) [18].

It has been widely documented that a like environment factors, mineral nutrition particularly nitrogen plays an important regulative functional role in the plant system through synthesis and translocation of growth hormones which generally act as stimuli for certain steps of growth and development (Beringer, 1980) [6]. Nitrogen is considered to be an essential consistent required for synthesis of protein, chlorophyll and other organic compounds of physiological significane in the plant system (Havlin *et al*., 2016) [13].

Jack *et al*. (2011) [14] reported that vermicompost contains significant quantities of nutrients, a large beneficial microbial population and biologically active metabolites, particularly gibberellins, cytokinins, auxins and group B vitamins which applied alone or in combination result in better growth of crops. Vermicompost helps in maintaining soil fertility since the mineral elements contained in it were changed to available forms that could be readily taken up by plants such as nitrates, exchangeable phosphorous, soluble potassium, calcium, manganese etc. It is also a fact that nutrients in organic manures are released to the plant via the activities of soil microbes. This must have occurred in a more efficient and continuous manner when a combination of vermicompost and FYM with vermiwash were used.

The possible reason for the increase in the growth parameters by application of higher level of nitrogen might be due to more accumulation of nitrogen content in plant which in turn resulted in more synthesis of nucleic acids, amino acids, amide substances in growing regions of meristematic tissues ultimately enhanced multiplication of cell division and there by increased in the growth attributes. Similar results were recorded by Pagar *et al*. (2016) [23], Javiya *et al*. (2019) [16], Kumar *et al*. (2020) [19], Prajapati *et al*. (2022) [25] and Chaudhary *et al*. (2023) [7].

Yield attributes and yield

Application of 75% RDF + vermicompost (1.25 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 75% RDF + FYM (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, vermicompost (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, FYM (10 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, RDF 100%, 50% RDF + vermicompost (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 50% RDF + FYM (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage and two vermiwash spray @ 5% (at tillering stage & jointing stage) significantly increased yield attributes *viz*., number of effective tillers $plant^{-1}$, number of grains ear^{-1}, ear length and test weight over control. Sources of nitrogen significantly affected the yield components. The beneficial effect of organic manure *i.e*. FYM and vermicompost decreases nitrogen losses and provides slow release of nitrogen to plant. Higher recovery of nitrogen may be possible when the nitrogen is made available to the plant over longer periods and by reducing nitrogen losses.

The application of vermicompost and FYM and vermiwash is than other treatments expected to supply nutrients and growth promoters in a more continuous manner which increased the grow that tributes leading to higher photosynthesis and translocation of photosynthates towards sink as indicated from the yield attributing characters and grain yield. It is also a fact that nutrients in organic manures are released to the plant via the activities of soil microbes. These products had a combined availability of nutrients, microorganisms and plant growth regulators, which promoted growth and hence increased yield attributes of barley. It is well established fact that yield component in a crop is outcome of complimentary interaction between vegetative and reproductive growth of the crop.

Maximum grain, straw and biological yield was recorded with application of 75% RDF + vermicompost (1.25 t ha^{-1}) + vermiwash spray @ 5% at tillering stage which was significantly higher over vermicompost (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, FYM (10 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, RDF 100%, 50% RDF + vermicompost (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage, 50% RDF + FYM (5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage and two vermiwash spray @ 5% (at tillering stage & jointing stage) and control but it was remained at par with the application of 75% RDF + FYM (2.5 t ha^{-1}) + vermiwash spray @ 5% at tillering stage. The higher grain and straw yield with application N through different neem cake with fertilizers might be due to enhancement of growth parameters attributed to higher yield parameters due to higher availability and steady supply of nutrients in these treatments. These results indicated that the increase in grain and straw yield was related to availability of nutrient mainly nitrogen by vermicompost was helped in reducing the leaching and volatilization losses there by accelerated the availability. Similar results were recorded by Pagar *et al*. (2016) [23], Dekhane *et al*. (2017) [8], Javiya *et al*. (2019) [16], Kumar *et al*. (2020) [20], Patel *et al*. (2021) [24], Kumar *et al*. (2022) [18], Prajapati *et al*. (2022) [25] and Chaudhary *et al*. (2023) [7].

Enhanced vegetative growth in terms of leaf area index, number of leaves per plant and biomass accumulation provided more sites for the translocation of photosynthates and ultimately resulted in increased yield attributing characters. The beneficial effect of FYM and vermicompost on yield attributes may probably due to enhanced supply of macro as well as micronutrients during entire growing period of crop season which led to much greater assimilation of food and its subsequent partitioning in sink. The availability and optimum supply of nutrients of crop favorably influenced the flowering and seed formation which ultimately increased the number of grains ear^{-1}. Similar results were also reported by Aatif *et al*. (2017) [2].

The significant increase in straw yield due to application of FYM and vermicompost at different time could be attributed to the increased growth of vegetative portions possibly as a consequence of higher mineralization of nutrients and absorption through voluminous root system and resulting in better luxuriant shoot development. Similar results were reported by Gupta *et al*., (2019) [12].

Table 1: Effect of organic and inorganic fertilizer on growth parameters at growth stages of barley

Treatments	Plant height (cm)			Dry matter accumulation (g $plant^{-1}$)		
	45 DAS	90 DAS	Harvest	45 DAS	90 DAS	Harvest
Control	31.52	49.71	55.12	4.97	48.91	58.21
RDF 100%	44.91	75.23	80.59	7.49	71.92	85.59
FYM (10 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	45.15	75.71	81.01	7.57	72.16	85.87
Vermicompost (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	45.20	75.80	81.21	7.61	72.26	85.99
75% RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	49.81	84.51	89.41	8.44	79.78	94.94
75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	49.82	84.64	89.80	8.45	79.99	95.19
50% RDF + FYM (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	40.32	66.34	71.80	6.63	63.87	76.00
50% RDF + Vermicompost (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	40.43	66.68	72.04	6.66	64.12	76.31
Two Vermiwash spray @ 5% (at tillering stage & jointing stage)	35.68	57.93	63.03	5.78	56.19	66.87
S.Em±	1.37	2.64	2.59	0.27	2.34	2.79
CD (p=0.05)	4.10	7.92	7.77	0.80	7.03	8.36
CV (5%)	5.57	6.47	5.91	6.50	7.23	6.00

Table 2: Effect of organic and inorganic fertilizer on yield attributes of barley

Treatments	Yield attributes			
	Number of effective tillers at harvest (m^{-1} row length)	Length of ear	Number of grains ear^{-1}	Test weight (g)
Control	38.33	5.48	30.23	35.29
RDF 100%	55.37	7.85	43.66	50.97
FYM (10 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	56.58	7.88	43.87	51.06
Vermicompost (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	57.06	7.95	44.23	51.46
75% RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	61.82	8.67	48.62	56.78
75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	62.94	8.69	48.84	57.07
50% RDF + FYM (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	50.11	7.06	38.86	45.25
50% RDF + Vermicompost (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	51.43	7.10	39.24	45.68
Two Vermiwash spray @ 5% (at tillering stage & jointing stage)	44.17	6.31	34.45	40.16
S.Em±	1.93	0.22	1.29	1.46
CD (p=0.05)	5.78	0.67	3.86	4.37
CV (5%)	6.28	5.20	5.39	5.24

Table 3: Effect of organic and inorganic fertilizer on yield of barley

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Grain	Straw	Biological	
Control	3177	3748	6925	45.89
RDF 100%	4504	5315	9819	45.87
FYM (10 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	4622	5436	10058	45.95
Vermicompost (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	4841	5258	10098	47.94
75% RDF + FYM (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	4982	5878	10860	45.87
75% RDF + Vermicompost (1.25 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	5012	5914	10926	45.87
50% RDF + FYM (5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	3944	4677	8621	45.74
50% RDF + Vermicompost (2.5 t ha^{-1}) + Vermiwash spray @ 5% at tillering stage	4073	4807	8880	45.87
Two Vermiwash spray @ 5% (at tillering stage & jointing stage)	3577	4221	7798	45.90
S.Em±	142	155	225	1.00
CD (p=0.05)	425	466	675	NS
CV (5%)	5.75	5.34	5.19	5.83

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