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Effect of Integrated Nutrient Management on Growth and Yield of Food Barley (*Hordeum vulgare*) Variety in Toke Kutaye District, West Showa Zone, Ethiopia

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Abstract

Declining soil fertility is one of the major problems causing yield reduction of food barley in West Showa. Therefore, considering this in view field experiment was carried out to determine the combined effects of farm yard manure (FYM) and inorganic NPS on growth, yield and yield components of food barley at Toke Kutaye District. The experiment was laid in randomized complete block design with four replications. Generally, analysis of variance showed significant difference among treatments for most of traits recorded. Markedly, application of 12 t FYM ha^{-1} combined with NPS (33.4:66.6% NPS:FYM) gave higher number of tillers from 0.25 m^{-2} was 270 effective tiller and 13 effective tiller plant^{-1}) gave the respective. The higher plant height (90 cm) was obtained from the application 75:25% NPS:FYM. Higher panicle length, panicle weight and total kernel weight of barley were recorded with application 50:50% NPS:FYM. The higher grain and biomass yield (6496 and 15917 kg ha^{-1}) of barley were harvested from 66.6:33.4% NPS:FYM at Dada Galan kebele; in Toke Kutaye District. Application of 66.6:33.4% NPS:FYM gave optimum yield and economic return and recommended for barley production in this area and similar agro-ecologies.

Keywords: NPS; FYM; Food barley; Yield component; Yield

Introduction

Barley (*Hordeum vulgare* L.) ranks fourth among cereals in the world and is grown annually on 48 million hectares in a wide range of environments [1]. In Ethiopia, barley is an important food crop in the highland parts and the second largest barley producer in Africa, next to Morocco, accounting for about 25 percent from the total crops [2]. It is at 2005, 100 countries participated in the world and produced 138 mil t from 57 ha mil [3]. It was reached in Ethiopia; it has been grown for 5000 years around Tibet and the Andes on the mountain slopes [4] and it is used for emergency crop while food shortage in September matures early [5]; the Second largest barley producer 90% in Africa [6] and the fifth most important cereals crop in total production [3]. The features of barley production in Ethiopian includes: high tillering capacity; tolerance to marginal soil conditions; insect, disease and frost. It is below, 1.3 t ha^{-1} and potential yield goes 10 t ha^{-1} can be obtained under serious management at experimental plots. MOA use of farm yard manure with low rates of mineral fertilizers could be one alternative solution for sustainable soil fertility management and barley production [7]. Shata et al. [8] use of chemical with organic fertilizer at optimum level, reduce the amount of chemical fertilizer. Limited agronomic studies in line to integrated nutrient management practices and recommend best practices in order to maximize yield [9].

Materials and Methods

Description of the study site

Toke Kutaye District is located in West Showa Zone, Oromia National Regional State. The climate is classified into three agro ecological zones are high land 17%, Midland 65% and low land 18% [10]. Research site altitude 1900-2850 m.a.s.l. and mean annual temperature: 16-29°C. The average annual rainfall 1291 mm. The site major crop plant production first is Barley 2.5-3 t ha^{-1} by farmers trial and followed Wheat 2-2.5 t ha^{-1} [11] (Figure 1).

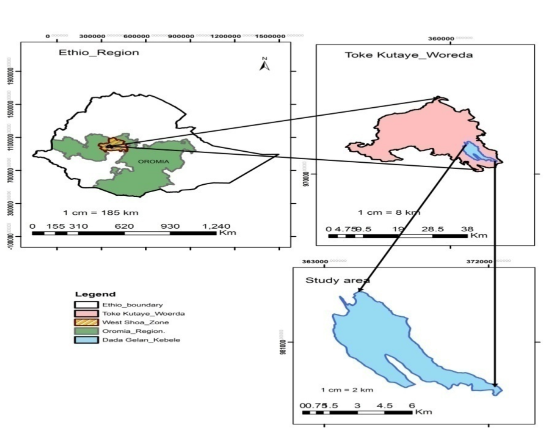

Figure 1: Map of the study area (Dada Gelan) Kebele in Tokke Kutaye District, west Showa.

Experimental treatments and design

The improved seed food barley variety (EH-1493) obtained from Holetta Agricultural Research Center was used. The experiment was laid in randomized complete block with four replications. The FYM (Cattle manure and urine composited) was used for the experiment applied all three weeks before planting while NPS (N=18, P=38 and S=7 composition) or 50 N kg ha^{-1} and 100 PS kg ha^{-1} fertilizer was being applied at planting of barley. The eight treatments of integrated nutrient management rates are as follows: 0% (control); 100% NPS; 100% FYM (12 t FYM ha^{-1}); 50:50% NPS: FYM; 75:25% NPS: FYM; 25:75% NPS: FYM; 66.6:33.4% NPS: FYM; 33.4:66.6% NPS: FYM.

Soil sampling and analysis

The soil samples of the experimental site were collected two times. The soil sample was collected from each treatment in four replications and composited to eight soil samples for the treatments and was air dried ground using a pestle and a mortar and allowed to pass through a 2 mm sieve and analyzed for the selected physicochemical properties using standard laboratory. Organic carbon content was determined by the volumetric method [12]. Total nitrogen was analyzed by Micro-Kjeldhal digestion method with sulphuric acid [13]. The pH of the soil was determined according to FAO [14]. The cation exchange capacity (CEC) was measured after saturated the soil with 1 N ammonium acetate (NH_4OAc). Available phosphorus was determined by the Olsen's method using spectrophotometer [15]. Particle size distribution was done by hydrometer method (differential settling within a water column) according to FAO [14] using particles less than 2 mm diameter and soil particle size determination by Bouyoucos hydrometer method [16].

Experimental procedures

The plot size was 3 m × 2 m=6 m^2. An improved seed of food barley (EH-1493) was used for planting in July 25, 2016. The field was prepared with conventional methods using oxen plough three times. The spacing of food barley variety was 20 and 2 cm between rows and plants respectively. The seed rate used was 125 kg ha^{-1}.

Data Collected and Measurements

Phenological data

Days to 50% emergence: The number of seedling per 0.25 m^2 in each plot was counted randomly from central rows in each net plot area by using 0.5 × 0.5 m quadrate and scored. Days to 50% flowering was recorded as a number of days from sowing to the date on which 50% of the plants in a plot reached. Days to 90% physiological maturity was calculated as a number of days from sowing to the date on which 50% of the plants in a plot reached.

Growth parameters

Leaf area where it was measured in the field linear dimensions of leaves LA=L*W*b and leaf area index (LAI) was measured by the area of leaves (single sided) divided to covering a given area of ground. Plant height was measured (cm) from five plants sampled randomly from the central rows one week before harvesting and the total measured plant height was summed and divided by the number of plants to get the average height of each plant. Number leaves plant^{-1} on the main shoot (MS) and each of the tillers were counted. Number of tillers plant^{-1} was counted as total number of tillers and effective tiller plant^{-1} at the milking stage after 100% flowering completed.

Yield and yield components

Spike length of barley was measured from the main tiller in centimeter from base to tip and divided by the number of ten plants and the panicle length per plant was obtained. Panicle weight was measured from 10 matured plants with samples. Number of Kernel per panicle was counted from the main tiller plant by taking ten samples of each plant from central net plot and averaged over ten plants.

The thousand-seed weight of barley was counted and expressed in gram. Total above ground biological yield was harvested and weighted from each plot, after sun drying and then biomass per plot was converted into hectare basis (kg ha^{-1}). Grain yield measured from each plot in kg of the eight central rows adjusted to 10% moisture level and converted to kg ha^{-1}, used for the analysis.

Harvest index was the ratio of yield to total plant biomass (above-ground biomass) multiplied by 100 and expressed in percentage.

Analysis of variance

Two-way analysis of variance was carried out according to Gome and Gomez [17] using statistical analysis computer software (SAS, 2004) and genstat (GenStat, 2012). Mean separation was computed using Least Significance Difference (LSD) at 5% probability level [18] Simple correlation was generated using Statistical Analysis Software 9.0 (SAS, 2004) to examine the relationship between different yield and yield components of food barley.

Economic analysis

For economic evaluation, partial budget, values to cost ratio (VCR) and marginal analyses were used based on the local market price of the Barley yield and fertilizer cost [19]. The economic analysis was performed to investigate the economic feasibility of the treatments. The average yield was adjusted downwards 10% to reflect the difference between the experimental plot yield of and the production yield by farmers.

Results and Discussion

Soil physicochemical properties of the experimental site

The particle size distribution of the soil was 4.1% sand, 15% silt and 80.9% clay dominated. The soil chemical properties of the experimental site are summarized in Table 1. The soil PH were higher (5.84) with application of 100% NPS and others ranged from were 4.75-4.99 with pre-soil and application of 100% FYM plots. The suitable PH range for most crops is between 6.5 and 7.5 in N availability is optimum [14]. The organic Carbon (2.987) and organic matter (5.14) of the soil were higher with application of 100% FYM. The organic matter and organic carbon of the soil after treatment application found in high range [20]. Higher 0.385% total Nitrogen was obtained with application of 25:75% NPS: FYM (Table 1). The total nitrogen of the soil ranged from 0.129 to 0.385 found in low to medium.

Treatment	PH	EC (dS/m)	OC %	OM %	N %	CEC (meq 100 g soil^{-1})	P (Mg kg soil^{-1})
0%	4.89	0.0651	1.652	2.84	0.243	10.399	16.523
100% NPS	5.84	0.0898	2.811	4.83	0.271	16.823	21.593
100% FYM	4.99	0.0755	2.987	5.14	0.245	16.397	23.733
50:50% NPS:FYM	4.84	0.0646	2.701	4.65	0.129	17.162	20.549
75:25% NPS:FYM	4.86	0.1071	2.783	4.79	0.329	16.559	24.066
25:75% NPS:FYM	4.87	0.0598	2.648	4.55	0.385	17.113	22.163
66.6:33.4% NPS:FYM	4.85	0.0636	2.775	4.77	0.241	16.391	21.819
33.4:66% NPS:FYM	4.83	0.06	2.728	4.69	0.273	17.260	19.376
Pre-soil tested	4.75	0.0757	1.793	3.091	0.218	10.699	17.897
FYM tested	8.63	3.4	18.165	31.32	5.168	49.376	57.425

Table 1: The particle size distribution and the soil chemical properties of the experimental site are summarized. EC=Electrical Conductivity; CEC=Cation Exchange Capacity; OC=Organic Carbon; OM=Organic Matter; P=Phosphorous; N=Nitrogen.

Effects of integrated nutrient management on phenological parameters of barley production

Days to 50% emergence: The mean day to 50% emergence of barley was significantly (P>0.05) affected by application of sole and integrated organic and inorganic fertilizer. The minimum (5) and maximum (6) days to 50% emergence of barley were obtained by 100% NPS and control. Because of, the chemical fertilizer was increased the reaction of germination and emergence than 0% treatments. Likewise, higher germination (94.46%) and vigor index (39.15) were obtained from application of (85 kg N ha^{-1}) [21]. This related N application then delayed the germination period likewise application of FYM on the trial site. Similarly, Tisdale et al. [22] reported that application of fertilizer near the seeds at the time of planting has the added advantage of stimulating seed germination and seedling emergence.

Treatment	Days to 50% emergence	Days to 50% flowering	Days to 90% maturity	Plant height (cm)	Number of leaf plant^{-1}	Leaf area (cm)	Leaf area index	Number of effective tillers plant^{-1}
0%	6a	77a	121a	47^{b}	5^{b}	30.32^{c}	0.303^{c}	5^{d}
100% NPS	5b	63f	110e	89^{a}	6^{a}	44.32^{ab}	0.443^{ab}	12^{abc}
100% FYM	6a	69b	114b	79^{a}	6^{a}	44.92^{ab}	0.449^{ab}	10^{c}
50:50% NPS:FYM	6a	65d	111d	87^{a}	6^{a}	48.36^{a}	0.484^{a}	13^{ab}
75:25% NPS:FYM	5b	64e	110e	90^{a}	7^{a}	42.08^{ab}	0.421^{ab}	11^{bc}
25:75% NPS:FYM	6a	67c	112c	85^{a}	6^{a}	42.57^{ab}	0.426^{ab}	12^{abc}
66.6:33.4% NPS:FYM	6a	65d	111d	87^{a}	6^{a}	44.74^{ab}	0.447^{ab}	10^{c}
33.4:66.6% NPS:FYM	5b	67c	112c	87^{a}	6^{a}	41.12^{b}	0.411^{b}	13^{a}
LSD (5%)	0.7264	0.393	0.4678	12.91	0.5567	7.1176	0.071	2.4329
CV (%)	7.1	0.9	0.7	10.8	6.18	11.44	11.44	15.16

Table 2: Effects of integrated nutrient management on days to 50% emergence, days to 50% flowering and days to 90% maturity and growth components of barley. Means within column followed by the same letter are not significantly different at P=0.05, NS=non-significant.

Days to 50% flowering: Longer (77) days to 50% flowering of barley was observed under non-fertilized plots. The present finding is in agreement with the research result of Manna et al. [23] who reported that combined application of NP and organic fertilizers promoted vegetative growth, leading to prolonged days to heading. The mean days to 50% flowering of barley was significantly (P<0.05) affected by application of integrated nutrient management (Table 2). Likewise, Ofosu and Leitch [29] reported the application of fertilizers of any source, regardless of their doses accelerated days to heading as compared to no fertilizer application. Similarly, Rashid et al. [24] reported that NP application significantly affects days to heading of barley. The three above treatments (Table 2) 100% NPS (63), 100% FYM (69) and 0% (77) days have significant difference between them by the 8% and 20% respectively. The lower days to 50% flowering of barley with fertilizer application was in agreement with Ottman who reported that increase in P rate decreased time to heading. Therefore, application of chemical fertilizer was reduced the number of days to 50% flowering of barley.

Days to 90% maturity: Significantly higher (121) days to 90% maturity of barley was obtained under non-fertilized as compared to sole or integrated nutrient management (Table 2). In contrary of this with control this might be attributed to the behavior of the fertilizer N which increases it delays maturity time was reported by Damene [25]. Likewise, Woinshet [26] reported that N delays maturity. In opposite of Damene was finding, Days to maturity decreased with increasing rate of P fertilizer. The application of integrated nutrient significantly ($P<0.05$) affected the number of days to 90% maturity of barley. The higher amount of chemical fertilizer applied, the lower days to maturity. Similarly, Gurmessa [27] found the number of days required to reach physiological maturity by the plants was also decreased with increasing rates of applied P, particularly for those plants without N. The application of NP fertilizer increased crop growth during the early growth period, hastened maturity and increased the number of mature heads at harvest time [28]. Likewise, Ofosu and Leitch [29], however, the application of fertilizers of any source, nevertheless of their doses speeded days to maturity as compared to no fertilizer application.

Effects of integrated nutrient management on growth parameters of barley production

Plant height: Application of integrated nutrient management was significantly ($P<0.05$) affected mean plant height of barley. The T_5 treatment (75:25% NPS:FYM) produced the tallest plants (90 cm) and the minimum (47 cm) plant height was recorded for the control. The results indicated that increased organic and inorganic fertilizer application rates have obvious effect in increasing vegetative growth of crop pants. The result of this experiment agreed with the finding of Amanuliah and Maimoona [30] who reported that the use of increased rates of FYM and N increased plant height and the shortest plants recorded from the control treatment. Similarly, Getachew [31] reported that the use of organic manures in combination with mineral fertilizers maximized the plant height than the application of inorganic fertilizers alone. In agreement, with this result, Ofosu and Leitch also reported that plant height of spring barley increased with organic manure application as compared to inorganic fertilizer alone. Significantly higher mean plant height was obtained with application of sole and integrated organic and inorganic fertilizer which was in agreement with Rashid et al. plant height was linearly increased with increasing levels of N fertilization. Similarly, Harris [32] reported plant height, on each treatment with increase of NKP rate and animal manure application. This result support the findings of earlier investigators [33], among the INM practices, application of 75% recorded significantly taller plants.

Number of leaves per plant: Application of integrated nutrient management was significantly ($P<0.05$) affected mean number of leaves per plant (Table 3). Significantly higher number of leaves plant^{-1} of barley was obtained from sole and integrated nutrient applied T_5 (7 receiving 75:25% NPS: FYM). Similarly, Harris reported higher number of leaves throughout each treatment with increased of NKP rate and also increased moderately in response to increasing animal manure application. But, Brima [34] stated that mean number of leaves per plant was significantly affected by only NPK. Therefore, the number of leaves plant^{-1} of barley was higher with application of sole and integrated nutrient management.

Leaf area: Significantly higher (48.36 cm) and lower (30.32 cm) leaf area of barley were obtained from application of 50:50% NPS: FYM and control, respectively (Table 3). These results were in agreement with the findings of Anjhu [35] leaf area plant^{-1} was observed in the control. The application of integrated nutrient management was significantly ($P<0.05$) affected mean leaf area of barley. Direct measurement method of LA such as destructive sampling; give more exact LAI values [36]. Similarly, Ryan et al. reported application of nitrogen increased leaf area and leaf area duration. The relationship of this finding and the current treatment was by application 50:50% NPS: FYM (highest and it has excess N). Likewise, Anbessa and Juskiw reported leaf area of barley cultivar increased by the application of N fertilizer [37].

Leaf area index: Leaf area index is used to evaluate many processes such as canopy, Photosynthesis and evapotranspiration which play an important role in the transformation of energy and mass between the atmosphere and plant canopy [38]. The leaf area index of barley was significantly ($P<0.05$) affected by application of integrated nutrient management. Significantly higher (0.484) and lower (0.303) mean leaf area index of barley was obtained from 50:50% NPS: FYM application and non-fertilized, respectively. Likewise, application of nitrogen increased leaf area index. Similar observations were also reported by Ram et al. [39]. The results indicated that increased organic and inorganic fertilizer application rates have pronounced effect in increasing leaf area index of barley.

Number of tillering: The mean number of total tiller, effective tiller and tillers plant^{-1} of barley were significantly ($P<0.05$) affected by application integrated nutrient management. Similarly, Genene et al. reported greater tillering as well as higher percentage of survival of the tillers due to higher N application. Application of sole both integrated inorganic and FYM were gave significantly higher number of tillers as compared to non-fertilized barley. The result agrees with the Prystupa et al. [40] who reported that number of productive tillers/plant was affected significantly by NP fertilizer application. Sepat et al. [41] also reported significantly enhanced early vegetative growth in terms of increased the number of spike bearing tillers. Similarly, the production of plants more numbers of productive tillers m^2 at higher levels of NP [42]. Likewise, Ryan et al. reported application of nitrogen increased tiller formation. As well as the lowest tiller were 0% (125, 91 and 5) total tiller, effective tiller and effective tiller/plants and also 100% FYM (223, 201 and 10) total tillers, effective tiller and effective tiller/plant respectively. Similarly, application of 5 t ha^{-1} FYM combined with 75% inorganic NP gave the highest number of productive tiller m^2 (227 and 215) [43]. Kumar [44] reported that the number of total tillers plant^{-1} was significantly increased with application of nitrogen fertilizer. Generally, the higher number of tillers was contributed to increased production and productivity of grain yield and total dry matter of barley.

Effects of integrated nutrient management on yield and yield components barley production

Spike length: Significantly (P<0.05) higher mean spike length of barley was obtained from application of sole and integrated nutrient management as compared to non-fertilized barley. Application of 40 kg K_2O ha^{-1} significantly increased the spike length of barley [45]. Similarly, result was reported by Kumar et al. The same to this result the yield increase was to the extent of 33.4 percent over local and the increased yield of genotype DWRB-73 was mainly due to significant increase in spike length (9.4 cm) compared to BH-902 [46]. Therefore, application inorganic and organic fertilizer alone or integrated were produced taller spike length of barley.

Treatments	Spike length (cm)	Spike weight (g)	Number of kernel plant^{-1}	Thousand seed weight (g)	Dry Biomass(kg)	Grian Yield(kg)	Harvest Yield (%)
0% (control)	6^c	2.61^b	41^b	44^b	5396^f	1004^f	18.54^c
100% NPS	8^a	3.39^a	58^a	49^a	15704^a	6288^{ab}	40.03^b
100% FYM (12 t FYM ha^{-1})	7^b	3.57^a	59^a	49^a	8684^e	4042^e	46.54^a
50:50% NPS:FYM	8^a	3.75^a	64^a	53^a	13454^b	6150b^c	45.71^a
75:25% NPS:FYM	8^a	3.58^a	59^a	52^a	15579^a	6200^b	39.82^b
25:75% NPS:FYM	7^b	3.37^a	61^a	50^a	12275^d	5679^d	46.26^a
66.6:33.4% NPS:FYM	8^a	3.41^a	60^a	52^a	15917^a	6496^a	40.84^b
33.4:66.6% NPS:FYM	8^a	3.59^a	61^a	51^a	12875^c	5925^c	46.03^a
LSD (5%)	0.5752	0.4327	5.6405	4.5151	382.24	229.43	2.0099
CV (%)	5.089	8.6316	6.624	6.164	2.08192	2.98721	3.37743

Table 3: Effects of integrated nutrient management on yield and yield components of barley. Means within column followed by the same letter are not significantly different at P=0.05, NS=non-significant.

Spike weight: Significantly (P<0.05) higher barley spike weight was obtained from application sole and integrated nutrient management (Table 4). Similarly, Shekhawat et al. reported that considerable increase of spike weight of barley due to application of only potassium.

Number of kernel plant^{-1}: The mean number of kernel plant^{-1} was significantly (P<0.05) affected by application of 100% NPS and FYM and (50:50% NPS: FYM), 64 result the applied treatment indicated integrated nutrient management. Applications of sole and integrated nutrient management were produced higher number of kernel plant^{-1} as compared to non-fertilized. Likewise, application of 5 t ha^{-1} FYM combined with 75% inorganic NP gave the highest number (37 and 36.7) of grain number spike^{-1} [43]. Similarly, Arif et al. [47] have reported significant increases in the number of grain spike^{-1} by applying organic manures and inorganic fertilizer application alone. Sepat et al. reported significantly enhanced early vegetative growth, more number of spikes which consequently increased the number of spike of barley. Likewise, Kato and Yamagishi reported spikes density variety were higher in organically managed field than as well as increases in spike per plant could be the consequence of the increase in number of tillers per plant. Godara et al. [48] reported neither inorganic fertilizers nor organic sources alone can result in sustainable productivity. Therefore, a combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil.

Thousand seed weight: Significantly (P<0.05) higher 1000 seed weight was obtained firm sole and integrated nutrient application as compared to non-fertilized. The highest significant difference was obtained from between 0% and 50:50 NPS: FYM treatments where produced 44 g and 53 g respectively. Similarly, Abay and Dejene [49] reported (45 g) was obtained with application 5 t ha^{-1} FYM in combination with 25% recommended rate of NP fertilizer at Ghimbo while at Adiyo (44 g) was obtained with the application of 5 t ha^{-1} FYM in combination with 75% rate of inorganic NP. Lower thousand grain weight (36 g) was obtained at Ghimbo and Adiyo from the control plots. Similarly, Saidu et al. [50] also obtained the highest 1000 grain weight, from application of 5 t ha^{-1} FYM in combination with 50% inorganic NP while the lowest 1000 grain weight was recorded from no fertilizer application. Non-significantly lower thousand seed weight of barley was obtained from sole application of NPS and FYM as compared to integrated nutrient management (Table 4). This research finding has been showed good weight 1000 seed by combination of fertilizers. So, that neither inorganic fertilizers nor organic sources alone can result in sustainable productivity [48]. This justifies integrated application of inorganic and organic fertilizers had considerable contribution for thousand seed weight of barley, which might be due higher nutrient concentration both fertilizer sources when integrated. In contrary, Gurmessa [27] reported no response of thousand seed weight due to N or P application in Borona zone of Ethiopia.

Dry biomass yield: The dry biomass yield of barley was significantly (P<0.05) affected by application of integrated nutrient management (Table 4). Significantly higher dry biomass yield was obtained from higher rates of NPS applied as compared to FYM alone and control. The highest 15917 kg ha^{-1} dry biomass barley was obtained with integrated application of 66.6:33.4% NPS: FYM, which was in agreement with Ram et al. [39]. Likewise, the application of 5 t ha^{-1} FYM in combination with 75% inorganic NP gave the highest biomass yield of 8259 and 8065 kg ha^{-1} of barley at Adiyo and Ghimbo, respectively [43]. Similarly, Fergusson [51] founded greatest of total biomass (16020 kg ha^{-1}) with N fertilizer treatment of 150 kg N ha^{-1} at crop emergence with an additional application of 100 kg N ha^{-1} at Zadoks growth stage. The lowest (5396 kg ha^{-1}) dry biomass yield of barley was obtained from non-fertilized followed 8684 kg ha^{-1} by application 100% of FYM. Application of higher nitrogen increased dry matter of plants. Likewise, Shata et al. suggested that by the use of mixed chemical and bio fertilizers production can be kept at optimum level, the amount of chemical fertilizer to be used can be reduced. This result refers to recommended application INM ratio (50:50%) than the 0%; 100% FYM; 25:75% NPS.

Grain yield: The application of integrated nutrient management significantly ($P<0.05$) was affected mean grain yield of barley. Significantly higher (6496 kg ha^{-1}) grain yield was obtained from application of integrated nutrient application (66.6:33.4% NPS: FYM) followed by sole application recommended 100% NPS (6288 kg ha^{-1}). Similar observations were reported by Ram et al. [39]. This result was in agreement with Mitiku et al. who reported application of inorganic fertilizers (NP or NPK) with FYM gave a better yield of barley than the application of 100% inorganic fertilizers alone. Likewise, increase in grain yield by combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil (to holding water capacity, to control soil erosion, to keep soil moisture, to control soil cracking and drying then soil come to rehabilitation) [48]. Equally, Blaise et al. found higher yield with integrated use of chemical and organic fertilizers as compared to sole chemical fertilizer. In contrary, Fergusson found highest grain yield of 7030 and 8000 kg ha^{-1} with pure application of 150 kg N ha^{-1} at sowing and 21 days after crop emergence. Likewise, Gafar et al. [52] have demonstrated the beneficial effect of integrated nutrient management in justifying the deficiency of several macro and micro-nutrients which affected the grain yields. Application of optimum dose of integrated nutrients (50 N; 100 PS kg ha^{-1} and t ha^{-1} FYM) is fundamental for maintaining adequate supply of nutrients (OC, OM, P and N) for increased yield. Compared to the control yield (1004 kg ha^{-1}) treatment, the highest grain yield (6496 kg ha^{-1}) is increased by 547% due to the application of 66.6% NPS and 33.4% FYM compared to non-fertilized. Inorganic fertilizer enhances the soil fertility and is applied to promote plant growth, improve crop yields and support agricultural strengthening systems. The chemical fertilizer required to achieve optimum yield levels can be decreased with the application of organic [53]. The present trend of increase in yield with the combined application of organic and inorganic fertilizers over the control was in conformity with Parihar et al. [54]. Application of higher rates of nitrogen increased grain yield. Therefore, the use of integrated nutrient management for barley production is advisable for Toke Kutaye District and for farmers. Because combined application of Cattle farm yard manure and inorganic fertilizer is economically optimum than sole fertilizers application.

Harvest index: The harvest index was significantly ($P<0.05$) influenced by application of NPS and FYM. Significantly higher harvest index of barley was obtained with sole application and integrated nutrient management. Similarly, a mean harvest index of about 50% with a positive trend due to increasing N rate was previously reported by Taye et al. [55]. The highest harvest Index was obtained by application 100% FYM (0.4654) followed by 25:75% NPS: FYM (0.4626). The lowest significant harvest index was recorded from control. Likewise, Mitiku et al. [43] reported harvest index of barley was significantly influenced by (Table 3) the combined application of organic and inorganic fertilizer sources and the highest harvest, 47% at Adiyo and 45% at Ghimbo were recorded from the application of 5 t ha^{-1} FYM+50% inorganic NP [43].

Effects of integrated nutrient management of economic feasibility of barley production

The highest net benefit of EB 58,553 ha^{-1} and marginal rate of return 36.45% was obtained from application of 66.6:33.4 % NPS: FYM followed by EB 57781 ha^{-1} and marginal rate of return 2153% of barley gain from application of 100% NPS (Table 4). Similarly, Mitiku et al. reported that the application of 5 t ha^{-1} FYM+75% inorganic NP gave the highest net return which 15,859 EB ha^{-1} at Adiyo and 13,108 EB ha^{-1} at Ghimbo.

Treatment	Grain yield (kg ha^{-1})	Gross return (ETB ha^{-1})	Total cost (ETB ha^{-1})	Net profit (ETB ha^{-1})	Value to cost ratio	Marginal Return (%)
0%	1004	10166	3880	6286	1.62	
100% NPS	6288	63666	5885	57781	9.82	2153
75:25% NPS:FYM	6200	62775	6883.75	55891D	8.12	
66.6:33.4% NPS:FYM	6496	65772	7219.33	58553	8.11	36.45
50:50% NPS:FYM	6150	62269	7882.5	54386D	6.9	
33.4:66.6% NPS:FYM	5925	59991	8545.67	51445D	6.02	
25:75% NPS:FYM	5679	57500	8881.25	48619D	5.47	
100% FYM	4042	40925	9880	31045D	3.14	

Table 4: Effects of integrated nutrient management on economic feasibility of barley production. The price of NPS EB=14.54 kg^{-1}; Urea EB=5.51 kg^{-1}, Seed barley EB=11.25 kg^{-1}, Price of FYM EB=0.5 kg^{-1} D=dominated.

Conclusion

The aim of this study was to increase yield and yield components of barley production using integrated nutrient management in Toke Kutaye District. Uniform management practices were conducted across treatments starting from site selection up to end of the experiment. The physicochemical properties of the soil were improved with application of integrated nutrient management. The results of this study indicated that integrated nutrient management significantly improved yield and yield components of barley. The phenological and growth parameter of barley were improved with application of integrated nutrient management. Higher biomass and grain yield of barley were obtained from application of 66.6:33.4% NPS: FYM show that integrated nutrient management contributed for soil nutrient status improvement. The harvest index of barley was improved with application of integrated nutrient management. The yield and yield components of barley had positively significant associations. The highest net benefit of EB 58553 ha^{-1} and marginal rate of return 36.45% with values to cost ratio EB 8.11 per unit of investment of barley were obtained from application of 66.6:33.4% NPS: FYM ha^{-1}.

Recommendation

Integrated nutrient management had improved the food barley production at Dada Gelan kebele, in Toke Kutaye District. Based on the result of the investigation, the following recommendations are given for barley production from this study. Application 66.6:33.4% NPS: FYM ha^{-1} is recommended for barley production in Toke Kutaye district and to similar agro ecologies.

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