Effect of Zinc and Boron Fertilizers Application on Some Physicochemical Attributes of Five Rice Varieties Grown in Agro-Ecosystem of Sindh, Pakistan


Grain Quality Testing Laboratory, Southern-zone Agricultural Research Center, Pakistan Agricultural Research Council, Karachi, Pakistan
Department of Chemistry, University of Karachi, Pakistan
National Sugarcane Research Station, PARC, Thatta, Pakistan

Abstract: Besides NPK, zinc and boron fertilizers are needed to improve grain yield and quality with respect to physicochemical properties such as yield, thousand grains mass, protein and fat content. Responses of varieties may vary over micronutrient fertilization in conjunction with the recommended doses of N and P fertilizers. In this connection the experiment following randomized complete block design (RCBD) to assess the response in terms of physicochemical attributes of five rice varieties; IR6, IR8, DR92, DR83 and Shahkaar over Zn and B were conducted on research field at Dokri, Larkana (27°33'N, 65°16'E), Sindh, Pakistan. Average temperature recorded was around 42 to 49°C with an average rainfall 108 mm and 48% humidity. Zinc and B along with N and P fertilizer application @ 135 N (as Urea), 90 P (DAP), 10 Zn (as Zinc Sulphate) and 2 kg B ha⁻¹ (as Boric acid) were applied. The results showed that soils were heavy in texture, non-saline, moderately alkaline in reaction and low in organic matter. Micronutrients B, Zn, Cu, Fe and Mn found in the soils were low in at 0-15 and 15-30 cm soil depth. Higher TGM: 25.7g, 24.3g, 24.3g, 25.4g and 25.8g; paddy yield:12.6, 11.3, 10.9, 12.3 and 11.5 tons per hectare; protein 11.1, 10.7, 10.4, 10.5 and 10.9%; fat 2.5, 2.6, 2.6, 2.7 and 2.5% was found at T2 (N+P+Zn+B) in the varieties IR6, IR8, DR92, DR83 and Shahkaar respectively. Yield, TGM and protein significantly (p<0.05) increased within varieties at each treatment where as fat contents in all varieties were found to be non-significant (p>0.05).

Key words: Treatment effects %Zinc %Boron %Physicochemical properties %Rice Varieties

INTRODUCTION

Rice is an essential cash crop and one of the main export items of the Pakistan. It accounts for 6.4% of value added in agriculture and 1.4% in gross domestic product (GDP). High quality rice to meet both domestic demand and for exports is grown across the country. The exports from Pakistan contribute about 15% of the total foreign exchange earnings. Rice production in the world during 2011 has been reported to be 713 million tons including 4823 thousand tons in Pakistan [1].

Growth and yield of rice crop is a result of its interaction with environmental factors, soil conditions, availability of water and nutrients uptake from the soil. Rice crop needs seventeen essential nutrients. Most important among them are N, P, K, Fe, Mn, Zn, Cu and B. These nutrients are supplied to rice crop through the soil in the form of fertilizers and manures. To provide the required amount of nutrients to rice crop in appropriate time at cheaper rate is of paramount importance. This is also equally important to do the proper management practices for economic utilization of fertilizers and for supplying of essential nutrients to different varieties, soils and agro-climatic factors of lowland as well as up-land conditions of rice cultivation. Familiarity with most common visual deficiency symptoms of nutrients in rice crop is also essential for proper fertilizer application. It has been reported by [2-5] that most soils of Pakistan are of calcareous alluvium nature with dominancy of carbonates, low organic matter and high soil pH and deficient in...
several nutrient elements. Micronutrients deficiency such as zinc and boron is widespread in rice growing areas of
country that hamper substantial loss in yield and quality of
growing areas of rice grain with respect to protein and fat contents. Soils
deficient in micronutrients are not capable of nourishing
crop plant successfully and therefore low yield and
quality of crops are obtained [6]. Even an increase of 32%
in fertilizer application for last ten years, resulted in
unsatisfactory yield that was only 15%. Generally rice
crop plants show the deficiencies of Zn, Fe, Mn, Cu, and
B that reflect in low contents of these nutrient minerals in
rice grains [7]. Fertilizers particularly zinc and boron is
needed to increase uptake and total contents of essential
trace nutrients in rice grain. Response of varieties in terms of
some physicochemical attributes over zinc and boron
application in addition to recommended doses of major
fertilizers; nitrogen and phosphorus may vary. Therefore
present study was conducted to assess the responses of
rice varieties viz., IR6, IR8, DR92, DR83 and Shahkaar
with respect to physicochemical attributes over Zn and B
fertilizer application in addition to N and P.

MATERIALS AND METHODS

The experiment was conducted on Research Field of
Shaheed Benazir Bhutto Rice Research Centre (previously
R.R.I), Dokri at Larkana (27° 33′ N, 65° 16′ E), Sindh,
Pakistan. Average temperature recorded was around 44 to
49°C from to July and around 42°C in August with an
average rainfall 108 mm and 48% humidity. For each
cultivar a nursery bed of 3x3 m² separately was prepared.
Straw and dried leaves were spread on each nursery bed
and burnt. Paddy seed at the rate of 10 kg ha⁻¹ was sown
by broadcasting method from 7-10th May of each year and
nursery beds were irrigated with tube well water. Main
plot was divided into equal 45 sub-plots of 3x5 m² each
were designed to irrigate separately from main channel.
After randomized complete block design (RCBD)
demarcation of main field into sub plots the transplantation of rice seedlings was done on 20th-28th
June in 2009 and 2011 and on 7th July in 2011 due to
delayed water flow in irrigation system. Harvesting of
crops was done in October of each cropping season.

Fertilizer treatments @ 135 N, 90 P, 10 Zn and 2 B kg
ha⁻¹ were applied. Treatments (C: 390.2 g Urea as nitrogen
+ 281g of DAP as phosphorus; T1: 390.2 g Urea as N +
281g of DAP as P + 150g ZnSO₄ as Zn and T2: 390.2 g
Urea as N + 281g of DAP as P + 150g ZnSO₄ as Zn+ 17g
boric acid as B) were applied to each sub-plot. For nursery
bed Fertilizer all DAP (168.75 g) was applied as basal dose
before broadcasting seed and Urea 233 grams was applied
into two equal split doses 116.5g with DAP and remaining
116.5g when tillers reached to a height of 3 cms. After
30 days, the seedlings of each cultivar were transplanted
to their respective plot according to experimental
layout. Sowing was done by applying 9 cm plant to
plant distance. For each experimental plot of 15m² all DAP
(281g) was applied as basal dose before transplantation of
rice seedlings whereas Urea 390.2 g was applied in two
equal split doses; 195.1g after 20 days of transplanting
and remaining 195.1g was applied after 65 days of
transplantation or at panicle initiation stage before
flowering. Mixing of 150g of Zinc Sulphate (ZnSO₄) and
17g Boric acid (H₃PO₄) with one kilogram of dry soil was
done and then was broadcasted after twenty days of
transplantation along with first dose of Urea.

Before submerging the plots, fifteen composite soil
samples at 0-15 and 15-30 cm from each experimental plot
were drawn. Air-dried samples were ground, passed
through 2 mm sieve and preserved into polyethylene bags
to avoid contamination of moisture and other debris
material. Bouyoucos hydrometer, EC meter Model: Hi833,
Suntex pH meter Model: SP-34 was used for analysis of
soil texture, EC and pH, respectively. Whereas O.M
(Organic Matter), Zn, Cu, Fe, Mn and B were analyzed
using AB-DTPA method. Paddy samples of about one
kilogram in weight drawn from each plot were preserved
into polyethylene bags and marked accordingly, then
were brought to the Laboratory-Grain Quality Testing
Laboratory, PARC, Karachi, Sindh. Paddy yield was
determined using digital balance and methods No.30-10
and 46-12 of AACC [8] were used for analysis of total
protein and fat content (%) respectively. Thousand grain
mass (g) was determined using digital electronic seed
counter model No: 801.

The data were analyzed statistically using analysis of
variance (ANOVA) technique given by Steel and Torrie
[9]. A software SPSS-11 of this technique was used and
the Duncan test for mean differences within treatments
and within variety was done.

RESULTS

Soil Analysis: Results given in Table 1 revealed that
soil of the study area were clayey in texture at both
the soil depths. At 0-15cm mean percent of sand, silt
and clay particles were 20.35, 26.35 and 53.30%,
respectively. Whereas, at 15-30 cm depth average particle
size distribution found was 20.37, 24.34 and 55.29% for
sand, silt and clay, respectively. Soils were found
non-saline with an average electrical conductivity of
0.32dSm⁻¹ at 0-15cm and 0.49dSm⁻¹ at 15-30cm depth.
Table 1: Physicochemical characteristics of soil

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean (n:15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Texture</td>
<td>0-15 15-30</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>20.35 20.37</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>26.35 24.34</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>53.30 52.20</td>
</tr>
<tr>
<td>b) Textural Class</td>
<td>Clayey Clayey</td>
</tr>
<tr>
<td>c) Electrical Conductivity dSmG</td>
<td>0.32 0.49</td>
</tr>
<tr>
<td>d) pH</td>
<td>8.11 8.13</td>
</tr>
<tr>
<td>e) Organic Matter (%)</td>
<td>0.54 0.53</td>
</tr>
<tr>
<td>f) Micronutrient (µg g⁻¹)</td>
<td>B 0.75 0.66</td>
</tr>
<tr>
<td></td>
<td>Zn 0.46 0.46</td>
</tr>
<tr>
<td></td>
<td>Cu 0.59 0.53</td>
</tr>
<tr>
<td></td>
<td>Fe 5.96 5.54</td>
</tr>
<tr>
<td></td>
<td>Mn 0.93 0.89</td>
</tr>
</tbody>
</table>

Table 2: Effect of treatments and response of varieties on physicochemical Attributes

<table>
<thead>
<tr>
<th>Varieties</th>
<th>C (N+P)</th>
<th>T1 (N+P+Zn)</th>
<th>T2 (N+P+Zn+B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR6</td>
<td>23.3±0.2aB</td>
<td>24.3±0.2bB</td>
<td>25.7±0.2cC</td>
</tr>
<tr>
<td>IR8</td>
<td>22.5±0.5aA</td>
<td>23.5±0.5bA</td>
<td>24.3±0.5Ca</td>
</tr>
<tr>
<td>DR92</td>
<td>22.8±0.4aA</td>
<td>22.9±0.5aA</td>
<td>24.3±0.5bA</td>
</tr>
<tr>
<td>DR93</td>
<td>22.9±0.6aAB</td>
<td>24.1±1.2bC</td>
<td>25.4±0.4cB</td>
</tr>
<tr>
<td>Shahkar</td>
<td>22.9±0.4aAB</td>
<td>23.2±0.6aAB</td>
<td>25.8±0.4bC</td>
</tr>
<tr>
<td>IR6</td>
<td>7.3±0.6aB</td>
<td>9.3±0.1bB</td>
<td>11.5±0.1cB</td>
</tr>
<tr>
<td>IR8</td>
<td>7.8±0.5aB</td>
<td>9.1±0.6bB</td>
<td>11.3±1.1cB</td>
</tr>
<tr>
<td>DR92</td>
<td>6.8±1.0aA</td>
<td>8.6±0.9bA</td>
<td>10.9±0.3cA</td>
</tr>
<tr>
<td>DR93</td>
<td>7.8±0.2aB</td>
<td>10.5±0.3bC</td>
<td>12.3±0.1cC</td>
</tr>
<tr>
<td>Shahkar</td>
<td>7.3±0.6aB</td>
<td>9.3±0.6aB</td>
<td>11.5±0.1cB</td>
</tr>
<tr>
<td>IR6</td>
<td>10.0±0.4aB</td>
<td>10.7±0.3bC</td>
<td>11.1±0.1cC</td>
</tr>
<tr>
<td>IR8</td>
<td>9.8±0.2aAB</td>
<td>10.2±0.5bB</td>
<td>10.7±0.3cA</td>
</tr>
<tr>
<td>DR92</td>
<td>9.7±0.3aAB</td>
<td>9.8±0.4aA</td>
<td>10.4±0.4bA</td>
</tr>
<tr>
<td>DR93</td>
<td>9.5±0.3aA</td>
<td>10.2±0.5bB</td>
<td>10.5±0.4bA</td>
</tr>
<tr>
<td>Shahkar</td>
<td>10.0±0.2aB</td>
<td>10.4±0.2bB</td>
<td>10.9±0.2cB</td>
</tr>
<tr>
<td>IR6</td>
<td>2.6±0.1aA</td>
<td>2.6±0.01aA</td>
<td>2.5±0.2aA</td>
</tr>
<tr>
<td>IR8</td>
<td>2.6±0.01aA</td>
<td>2.6±0.2aA</td>
<td>2.6±0.1aAB</td>
</tr>
<tr>
<td>DR92</td>
<td>2.5±0.1aA</td>
<td>2.5±0.1aA</td>
<td>2.6±0.1aAB</td>
</tr>
<tr>
<td>DR93</td>
<td>2.8±0.2aB</td>
<td>2.7±0.4aB</td>
<td>2.7±0.2aB</td>
</tr>
<tr>
<td>Shahkar</td>
<td>2.5±0.1aA</td>
<td>2.5±0.01aA</td>
<td>2.5±0.1aA</td>
</tr>
</tbody>
</table>

Table 3: Analysis of variance (F-values) of following physicochemical attributes

<table>
<thead>
<tr>
<th>Source</th>
<th>Thousand grains Mass</th>
<th>Yield</th>
<th>Protein</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2</td>
<td>0.765</td>
<td>0.942</td>
<td>0.478</td>
<td>0.213</td>
</tr>
<tr>
<td>Corrected Model</td>
<td>26.584</td>
<td>132.856</td>
<td>7.499</td>
<td>2.217</td>
</tr>
<tr>
<td>Treatment</td>
<td>404.237</td>
<td>2249.096</td>
<td>90.253</td>
<td>0.177</td>
</tr>
<tr>
<td>Variety</td>
<td>40.363</td>
<td>181.169</td>
<td>16.233</td>
<td>0.909</td>
</tr>
<tr>
<td>Year</td>
<td>3.953</td>
<td>150.095</td>
<td>3.338</td>
<td>6.096</td>
</tr>
<tr>
<td>Treatment * Variety</td>
<td>10.408</td>
<td>8.382</td>
<td>1.925</td>
<td>0.726</td>
</tr>
<tr>
<td>Treatment * Year</td>
<td>6.177</td>
<td>2.635</td>
<td>2.071</td>
<td>0.775</td>
</tr>
<tr>
<td>Variety * Year</td>
<td>3.163</td>
<td>19.388</td>
<td>2.412</td>
<td>3.01</td>
</tr>
</tbody>
</table>

According to classification given by Ankerman and Richard [10] soils of experimental area were found moderately alkaline in reaction with an average pH of 8.11 at 0-15 and 8.13 at 15-30 cm depth. Organic matter content in soils 0.54 and 0.53% at 0-15 and 15-30cm soil depths respectively with reference to FAO [11] categorization was found to be low. Micronutrients (µg g⁻¹) found in the samples at 0-15 and 15-30cm depths, respectively were 0.75 and 0.66; 0.46 and 0.46; 0.59 and 0.53; 5.96 and 5.54; 0.93and 0.89µg g⁻¹ for B, Zn, Cu, Fe and Mn, respectively. On the basis of categorization presented by Soltanpur and Schwab [12], soils of the experimental area were found low in micronutrient contents. These results are in agreement with those obtained by Memon et al. [13] and Nazir [14].

**Physicochemical Attributes**

**Yield (tons ha⁻¹):** Data presented in Table 2 revealed that application of Zn and B at the rate of 10 and 2 kg ha⁻¹, respectively increased the paddy yield of the studied varieties. Three year’s (2009 - 2011) mean results of the study revealed that yield obtained at C (N+P), T1 (N+P+Zn) and T2 (N+P+Zn+B) was 8.7 ± 0.9, 10.7 ± 1.5 and 12.07 ± 0.7 tons ha⁻¹ in IR6; 7.8 ± 0.5, 9.1 ± 0.4 and 11.3 ± 0.1 tons ha⁻¹ in IR8; 6.8 ± 1, 8.6 ± 0.9 and 10.9 ± 0.3 tons ha⁻¹ in DR92; 7.8 ± 0.2, 10.5 ± 0.3 and 12.3 ± 0.1 tons ha⁻¹ in DR93; 7.3 ± 0.6, 9.1 ± 0.4 and 11.5 ± 0.1 tons ha⁻¹ respectively in Shahkaar. Statistical analysis of data in Table 2 showed influence of the treatment on yield within variety and among the varieties was found to be significant (p<0.05). Interaction studies expressed as F-Vales depicted in Table 3 showed that yield x treatment and yield x variety was highly significant (p < 0.001). Correlation among yield and yield contributing properties such as thousand grain mass and proteins was found to be significant p < 0.01. Differential responses of varieties...
Fig. 1: Effect of treatments over physicochemical attributes of varieties.

with respect to yield over each treatment are depicted in the Fig. 1 that revealed highest yield was response of IR6 when Zn and B in addition to N and P were applied.

**Thousand Grain Mass (g):** Data in Table 2 showed that mean 1000 grains mass obtained at C (N+P), T1 (N+P+Zn) and T2 (N+P+Zn+B) was 23.3 ± 0.2, 24.3 ± 0.2 and 25.7 ± 0.2 g in IR6; 22.5 ± 0.5, 23.5 ± 0.2 and 24.3 ± 0.5g in IR8; 22.8 ±0.4, 22.9 ± 0.5 and 24.3±0.5g in DR92; 22.9 ±0.6, 24.1±1.2 and 25.4 ± 0.4g in DR83 and 22.9 ±0.4, 23.2±0.6 and 25.8± 0.4g respectively in Shahkaar. Statistical analysis of data in Table 2 showed influence of the treatment on yield within variety and among the varieties was found to be significant (p<0.05). Interaction study, F-Vales depicted in Table 3 showed that TGM x Treatment and TGM x Varieties was highly significant (p<0.001). Correlation among TGM and yield and protein was found to be significant p<0.01. Varied responses of varieties with respect to TGM over each treatment are depicted in Fig. 1 that showed highest TGM of Sahkaar over T2 (N+P+Zn+B) was applied.

**Protein Content (%):** Data given in Table 2 revealed that mean protein content of cultivar recorded against three fertilizer treatments C = (N+P), T1= (N+P+Zn) and T2= (N+P+Zn+B) was: 10.0 ±0.4, 10.7 ± 0.3 and 11.1 ± 0.1% in IR6; 9.8 ± 0.2, 10.2 ± 0.5 and 10.7 ± 0.3 % in IR8; 9.7 ± 0.3, 9.8± 0.4 and 10.4± 0.4% in DR92; 9.5 ± 0.3,
10.2±0.5 and 10.5±0.4 % in DR83 and 10.0±0.2, 10.4±0.2 and 10.9±0.2%, respectively in Shahkaar. Statistical analysis of data in Table 2 showed influence of the treatment on protein percent within variety and among the varieties was found to be significant (p<0.05). Interaction interpreted by F-Values depicted in Table 3 showed that interaction of protein with treatment and variety was highly significant (p<0.001). Correlation among protein and yield and TGM was found to be significant (p<0.01). Each variety showed dissimilar responses with respect to protein percent and over each treatment as depicted in the Fig. 1, maximum contents in IR6 at T2 (N+P+Zn+B) were found.

**Fat Content (%):** Results given in Table 2 revealed that mean fat percent of cultivars investigated over fertilizer treatments C= (N+P), T1=(N+P+Zn) and T2=(N+P+Zn+B) was: 2.6 ± 0.1, 2.6±0.001 and 2.5 ± 0.2 in IR6; 2.6 ± 0.001, 2.6 ± 0.2 and 2.6 ± 0.1 in IR8; 2.5 ± 0.1, 2.5± 0.1 and 2.6 ± 0.1 in DR92; 2.8 ± 0.2, 2.7 ± 0.4 and 2.7± 0.2, respectively in DR83 and 2.5 ± 0.1, 2.5 ± 0.001 and 2.5 ± 0.1, respectively in Shahkaar. Statistical analysis of results of Table 2 revealed that influence of the treatment on fat percent within variety and among the varieties was found to be non-significant (p >0.05). F-values of table 3 showed that interaction treatment was found to be non-significant (p>0.05) and with variety it was significant (p<0.01). Correlation among Fat content, protein and yield and TGM was found to be non-significant p > 0.01. The maximum fat content in a cultivar DR83 over T1 (N+P) was recorded.

**DISCUSSION**

Nutrients accumulation begins soon after germination of rice seedlings in nursery bed and in main fields after transplantation. The content of accumulation of nutrients and their resultant effects are dependable of root growth. An uptake of these nutrient elements is in low amounts at early stage of planting but as the plants continues to grow their need for the nutrient raises. Phosphorus and nitrogen that help improving germination of root system and vegetation are major nutrients but the necessity of some other trace elements is also as important as macro as they also contribute in several metabolic processes and are critical for rice plants survival.

Out of four yield contributing attributes, TGM (thousand grains mass) of paddy rice expressed grams is an important component. TGM is influenced by balanced nutrient supply to rice. This attribute directly reflect the filled healthy grain and paddy yield. Several research studies conducted have revealed that Zn and B applied with in conjunction with N and P mass of 1000 grain of paddy and the yield. Application of (N+P+Zn+B) combination increased TGM over control, N and P [15, 16]. Differential 1000 paddy grain mass doesn’t only indicate the proper and imbalance supply of nutrient element from soil and the outer environment but also this may affect due to varied specific genetic behavior. Some varieties show higher and others lower TGM. Other study reported by Mondal et al. [17] showed that low and high 1000 grains mass among all studied varieties found was due to differential genetic behavior of rice plants. In present study significant responses of treatment and variety was found. Findings are in conformity of with the results obtained by Pervaiz et al. [18] and Shivay et al. [19].

Yield of paddy grain is a result of cumulative factors – environmental and fertilization that contribute to other yield components. Biswas et al.[20] revealed that varietal difference in paddy yield and his results showed yield difference was of because of the difference in genotypes. Kusutani et al. [21] and Dutta et al. [22] reported that cultivars produces higher number of effective tillers/hill and high number of grain/panicle gave higher paddy grain yield. Micronutrients such as Zn and B in rice fields have exerted beneficial effects not only over yield but also on quality of rice grain. Other studies, Yashbir et al. [27], Rashid and Ryan [24] and Mahnaz et al. [25] reported that application of Zn and B fertilizers in addition to N and P showed significant increase in yield and yield contributing attributes. Findings of the present study are in line with those obtained by Arif and Muhammad [26] and Ashraffuzaman et al. [27] who reported that significant effect of Zn and B on yield and variety.

Both Zn and B play key role for nucleic acid metabolism within plat system. Zinc is known to be metal activator for several enzymes- carbonic hydrogenase, alchohal dehydrogenase, superoxidase dismutase and ribonucleic polymerase. Protein content in rice grain in low zinc contents soils is affected due to restricted synthesis of auxin or indoleacetic acid (IAA) from tryptophane and ribonucleic acid synthesis [2]. Rice grain quality with respect to protein percent is directly correlated with the contents of N within plant [28]. Nitrogen application along with zinc significantly increased protein content of rice grain [29]. Juliano [30] investigated environmental influences on yield and yield components and quality of rice grain in relation to protein and fat contents. They reported that short period of growth and cloudy weather at the time of grain development particularly submerged surroundings,
are major factors increased protein percent. This is happens due to enhanced availability and uptake of N by plants and low volatilization losses of the element. But at the same time they reported that environmental factor such as soil type ambient temperatures at grain ripening stage and duration growth showed no-significant response over fat percent. Fertilize application and residual mineral nutrient elements present in soil and organic matter showed significant impact on protein percent of rice grain. Similar responses of protein and fat content were found in present study. The results of the present study are in agreement with those obtained by Hao Hu-Lin et al.[31] and Basu et al.[32] who reported that nitrogen uptake by rice plant root system ultimately increased protein percent of rice grain.

On dry basis estimates major around 20% fraction of fat exist in the rice bran and only less contents varying from 1.5 to 1.7% depending on genotype is present in white polished rice that primarily is found as non-starch lipids extracted using ether, chloroform-methanol and cold water-saturated butanol [33, 34]. Present study revealed that fat contents was also non-significant over treatments where difference of the years as the weather change have been found but at significant level of p<0.01. The results of the present study are in agreement with those obtained by Taira et al. [35] who reported that the contents of essential fatty acids are dependable over temperature (Changing seasons), when it increases the contents are increases but total oil content may be reduced.

CONCLUSION AND SUGGESTIONS

The result obtained from the study showed that application of Zn @ 10 and B @ 2 kg ha⁻¹ in addition to N @ 135 kg ha⁻¹ and P @ 90 kg ha⁻¹ increased the yield, 1000 grain mass and protein of the rice varieties. Often, it has been witnessed that farmers of rice growing areas do apply only Zn fertilizer @ 10 kg ha⁻¹ as an additional B have rarely been applied. Based upon the result it may be suggested that better yield and quality of rice irrespective of varieties may be obtained with B and Zn application in additional to N and P fertilizers.

REFERENCES