The present investigation was undertaken to evaluate the response of a suitable cultivar of dwarf wheat at optimum date of sowing, to different doses of macronutrients - N, P, K, Ca, and micronutrients, Zn, B, and Mo. The observations recorded have been detailed in the preceding chapter. Here attempt has been made to discuss the result collected from experiments.

The effect of dates of sowing on wheat varieties:

There was a significant difference due to different dates of sowing on the plant characters and days taken to maturity. The vegetative characters, such as, plant height and number of tillers were influenced by the different dates of sowing. Maximum height of plant (70.33 cm) and maximum number of tillers (4.33) were recorded by the crop sown on November 15. Thereafter with the delay in sowing these were found decreasing gradually.

The yield characters were also found to be influenced by the dates of sowing. Maximum number of ears per plant (4.48), length of ear (10.04 cm), number of grain per earhead (48.64) and yield of grain (39.67 qtl/ha) in quintal per hectare were recorded by the crop sown on November 15. While December 15
produced sowing/the best. The crop sown by October 31, germinates early and completes its pre-flowering period in about 60 days due to higher atmospheric temperature, whereas the crop sown by November 15, takes about 80 days to complete its pre-flowering growth, which is probably the normal period. Therefore, the shortening of pre-flowering period probably affected the yield and its attributes adversely. When the crop is sown by November 30 or December 15, no doubt, it grows well under low temperature like the one sown by November 15, its flowering period is shortened considerably. Because by the time it comes into flowering stage the atmospheric temperature goes higher (more than 20°C). As a result, the flowering period is cut down to about 3 days as compared to 23 days in case of crops sown on October 30 and November 15. This shortening of flowering period is therefore responsible for the reduction in yield attributes which registered reduced yield in the late sown wheat. Similar findings have been reported by Dubey and Lal (1971), Mehta and Mathur (1972). The response curve study indicated that the delay in sowing by 14 days from October 31 resulted maximum yield of grain.

Therefore it is concluded that for the maximum yield the crop should be sown by November 15. Chandnani (1953) also supported this view.

The crop sown by October 31, exhibited next best results in all observations but yield. In this crop there was danger of frost in the month of January which coincides with earing. Moreover the high temperature reduced tillering, number of ear and number of grain, As a result the ultimate grain yield was reduced.
These results are in full agreement with the report of Jain et al. (1963), and Mehta and Mathur (1972).

Effect of variety:

There was a significant varietal difference in case of all plant characters except the length of ear. The variety 'Safed Lerma' exhibited maximum height of plant, (70.44 cm) maximum number of tillers and ears per plant (4.28) while it recorded the least number of grain per ear. Moreover, presence of immature earhead at the time of harvest as well as least number of grain per ear resulted in the least yield (32.43 qtl/ha) of grain. Again as the dwarfness of the variety is controlled by single gene better vegetative growth might be due to its hereditary factor.

The variety 'Kalyan Sona' recorded maximum yield (36.95 qtl/ha) of grain which was influenced by the highest number of grain (49.37) per earhead. In regards to plant height 'Kalyan Sona' along with 'Sharbati Sonora' recorded shorter plants even than the 'Sonalika'. This shortness in structure might be due to its two gene dwarfness. Therefore, from the average data it can be concluded that 'Kalyan Sona' recorded highest yield. Similar reports were shown by Bharadwaj (1967), Kohli (1966), Gupta et al. (1969), Sandhu and Gill (1969).

The variety 'Sonalika' recorded highest weight of 1000-grain (41.82 gm) while it followed 'Kalyan Sona' in the number of ear per plant and number of grain per ear resulting lesser yield (35.85 qtl/ha) of grain than the 'Kalyan Sona'. But the
yield was higher than the 'Sharbati Sonora' (34.67 qtl/ha). The lesser yield of 'Sharbati Sonora' was attributed by its lesser weight of 1000-grain, number of ear, number of grain per ear than the 'Sonalika'. Kohli and Anderson (1967), Kohli (1969), Agrawal et al. (1972), all reported similar results.

Impact of sowing time on the yield of different varieties:

Different varieties acted differently with the delay in sowing. The outstanding feature of this investigation was that the variety 'Kalyan Sona' produced maximum yield in earlier sowing while on December 15 sowing it recorded minimum yield. The variety 'Sonalika' under late sowing outyielded all other varieties followed by 'Sharbati Sonora', 'Safed Lerma' and 'Kalyan Sona' respectively. Swaminathan and Singh (1972), from I.A.R.I., also reported similar findings in respect of 'Sonalika'.

Effect of micronutrient:

The overall effect of micronutrient was not found to be significant in respect of height of plant, while significant effect was noticed only at the age of 75 days in respect of number of tillers per plant. Further, the data indicated that only due to the effect of Zinc significant result in yield emerged. However, Boron and Molybdenum showed superior effect at 10 kg/ha and 50 gm/ha levels respectively, though it was not found.
significant statistically. Thus, except at 75 days in respect of tillers, the overall effect of micronutrient on vegetative characters was not significant. Deal and Engel (1965) also did not observe any effect on growth rate of wheat. The increased number of tillers due to micronutrient, specially Zinc at the age of 75 days, might be due to the fact that Zinc stimulated root growth. As a result the uptake of nutrients was efficient which resulted the production of greater number of tillers. Deal and Engel (1965) further reported similar findings.

The effect of micronutrient was significant in case of reproductive characters under study. From a comparative study of the data with the critical difference value calculated, it could be concluded that it was mainly the Zinc which induced significant effect. The number of grain per ear increased with the increasing level of Zinc producing maximum number of grain (50.63) at 20 kg/ha dose. Thereafter, a decline was noticed. A similar trend was revealed in respect of weight of 1000 grain where maximum was 41.56 gm at the dose 20 kg per hectare in the November sowing. December sowing too recorded 40.46 gm of 1000-grain weight due to 20 kg Zn/ha level, while Boron at 10 and 20 kg per hectare level, and Molybdenum at 100 gm/ha dose showed an increasing tendency at December 15 sowing. Thus, on an average the effect of Zinc was maximum followed by Molybdenum and Boron. Therefore, more number of ears, more grain, and more weight of 1000 grain collectively resulted more yield of grain at 10 as well as 20 kg Zinc per hectare level. Beyond this the effect was not beneficial. Thus, 20 kg of Zinc per hectare recorded the maximum yield (32.33 qtl/ha) of grain in November sowing and only 27.80 qtl/ha
grain yield in December sowing. Increased yield of grain due to the effect of Zinc was reported by Konwar (1966, 1972), Sadaphal and Das (1956, 1961) and Dhillon et al. (1971).

Further, it could be concluded that Boron and Molybdenum could not produce significant beneficial results. Similar results were also reported by Kurchani et al. (1968) and Dhillon et al. (1971).

However, Boron at 10 kg level in both the sowing dates indicated more yield of grain than the Control. In November sowing Molybdenum at 50 gm/ha and in December sowing 150 gm/ha produced slightly better yield of grain than the Control. Increased yield of grains due to Boron and Molybdenum was also reported by Asana et al. (1964), Ghose et al. (1964), Mehrotra et al. (1967), Patil et al. (1972).

Thus, the data revealed that the variety 'Kalyan Sona' possessed very high degree of susceptibility towards Zinc and moderate to low in case of Boron and Molybdenum. Similar conclusion was also drawn by Patnaik (1970).

There was a significant difference due to the effect of sowing dates. In all respects crop sown by November 15 produced superior results to the December sown crop. This was mainly due to the fact that the optimum time of sowing for wheat specially for the variety 'Kalyan Sona' lies in the first fortnight of November. The variety as a late sown crop could not show its performance efficiently.

The response curve study indicated that among the different micronutrients under study, maximum yield as well as maximum net profit was expected from Zinc in November sowing. Zinc at 17.5 kg/ha and 10.7 kg Zn/ha gave maximum yield and maximum net profit respectively.
Effect of Nitrogen:

There was an increase in the plant height with the application of high dose of Nitrogen. The dose 120 kg/ha produced maximum height of plants. Beyond this dose decrease in height was indicated. The high doses of Nitrogen increased the vegetative growth of plants by multiplication and cell extension of meristematic tissue (Meyer and Anderson, 1959). This is also in conformity with the findings of Raheja et al. (1960), Saxena et al. (1965), Misra et al. (1972), who reported the increased height of plant with the increased dose of Nitrogen.

The Nitrogen is well known for luxurient vegetative growth of the plants and it was evident from this study that increasing the Nitrogen from lower to higher dose additional straw yield could be obtained. The plots treated with 120 kg N/ha produced 11.43 qtl/ha more straw yield than 40 kg N/ha, 3.86 quintal more than 80 kg N/ha level and 22.93 quintal more straw yield than the Control. It has been recognised to be dependent mostly upon the number of tillers. The number of tillers was found increasing progressively with the increase in doses. The higher doses of Nitrogen, 120 kg/ha and 160 kg/ha, produced the maximum number of tillers as compared to the lower doses. Several authors, such as, Singh (1952), Raheja and Mishra (1955), Rai and Prasad (1962), Sinha (1963), Garg and Jain (1963), and Sharma (1968) have reported increased number of tillers with the increased Nitrogen doses.
In case of other yield attributing characters, higher doses of Nitrogen produced higher number of ears. It was clear that the probability to produce more ears was more if number of tillers were more. Holmes and Tahir (1957), and Singh and Gupta (1969) also reported the increased number of ears with the increased dose of Nitrogen.

The length of earhead increased progressively with the higher doses of Nitrogen. The doses 40, 80, 120, and 160 kg N/ha all reported longer earhead than the control, of which 160 kg/ha topped, which was almost at par with 120 kg N/ha. Similar observations have been reported by Ranjan and Bajpai (1958), Singh and Sharma (1969).

The application of higher doses of Nitrogen resulted additional increase in the weight of 1000 grain. The increase was gradual exhibiting maximum at 120 kg N/ha. Beyond this the weight of grain showed a diminishing trend. Several authors such as, Saxena et al. (1968), Gill and Batra (1968), Agrawal et al. (1972) all reported increase in 1000-grain weight due to Nitrogen application.

The application of high doses of Nitrogen increased the grain yield of wheat. The maximum yield of grain (45.16 qtl/ha) was obtained with 120 kg N/ha level which was almost double than that of the Control (23.23 qtl/ha). But further increase in doses exhibited decline in the yield. However, increased yield of grain was due to the increased weight of 1000-grain, more number of ear, and longer earhead. Increased yield through Nitrogen application has been reported by a good number of workers, such as, Raheja et al. (1960), Arakeri (1961), Gautam
(1961), Verma (1961), Relwani (1962), Jain et al. (1963), Singh (1964), Pathak (1965), Swaminathan (1967), Bhardwaj and Wright (1967). The fact that the 120 kg Nitrogen produced maximum yield of grain followed by 160 kg N/ha, 80 kg N/ha and 40 kg N/ha in order is in conformity with Sinha and Roy (1969-), Singh and Sharma (1969), Singh et al. (1971), Mathur et al. (1971), Sandhu and Gill (1972), Agrawal et al. (1972). These workers supported that 120 kg N/ha produced maximum yield of grain.

Therefore, it could be concluded that for the increase yield of grain of wheat Nitrogen plays a vital role, which limited the yield. Borlaug (1957) also supported this view. In this study 129.20 kg/ha level was expected to give maximum yield, whereas, 120.8 kg N/ha was expected to give maximum net profit.

Effect of Phosphorus:

The application of Phosphatic fertilizer produced increased height only at 80 kg/ha level. In other doses Phosphorus did not produce taller plants. Thus, no significant increase in height was noticed. Singh and Govil (1968) also did not find any significant increase in height. However, at 80 kg P₂O₅/ha increase in plant height was noticed. McNeal (1954), Motowani (1958), Singh and Prasad (1966) reported increase in plant height due to phosphate application.

Phosphate dose at 40 kg/ha recorded increase in the number of tillers. The results were in conformity with the findings of Mallik et al. (1965), Saxena et al. (1965) and Bondale (1967). However, the ear bearing tillers increased gradually up to the
80 kg P₂O₅ per hectare level. But beyond this further increase in dose caused decrease in the ear numbers. Singh (1964), and Pathak (1965) have reported increase in the number of ear bearing tillers due to Phosphate application. The results further indicated that increased plant height as well as production of more tillers by 80 kg P₂O₅ per hectare level decidedly resulted increased yield of straw at this level. The plots treated with 80 kg P₂O₅/ha produced 45.93 qtl/ha of straw in comparison to the Control (43.33 qtl/ha) or 120 kg/ha (44.17 qtl/ha) while the level 180 kg P₂O₅/ha depressed the straw yield. Singh and Gupta (1969) also reported increased straw yield by Phosphate application.

The application of 80, and 120 kg P₂O₅ per hectare level increased the grain test weight by (42.93 - 37.83) 5.10 gm and (42.36 - 37.83) 4.53 gm respectively than the Control. The other levels though produced higher weights of 1000-grain were not found to be significant. Singh (1964), Mallik et al. (1965) have reported increase in weight of 1000-grain due to Phosphate application while Singh and Govil (1968) did not find any significant difference in yield contributing factors of wheat at increasing levels of Phosphorus. The application of Phosphorus could not influence the length of earhead significantly. Similar observations were also reported by Mallik et al. (1965) and Singh (1967).

Therefore, more number of ear, and higher weight of 1000-grain resulted increased yield of grain of wheat. Thus, 80 kg P₂O₅/ha level increased the yield by (25.56 - 23.23) 2.33 quintals over Control. So it could be concluded that Phosphate
application, influencing favourably the number of ear producing tillers, and thousand grain weight, might beneficially increase the yield of grain. The results are in full conformity with Sinha and Roy (1969). However, maximum grain yield and maximum net profit were expected from the levels 82.40 kg P$_2$O$_5$/ha and 66.4 kg P$_2$O$_5$/ha respectively.

Effect of Potash:

The vegetative characters, such as, plant height, number of tillers were not influenced significantly by the application of different doses of Potash. This might be due to the fact that Assam soil is not deficient in this element. Moreover, the cereal crops remove considerably lesser amount of Potassium than do legumes (Pillai, 1967). Further for vegetative growth the importance of Potash was much less in comparison with Nitrogen. However, an increasing trend with the application of 80 kg K$_2$O/ha level was noticed in respect of number of tillers per plant. This level also produced similar effect in the production of number of ear bearing tillers. The increase in the number of ear bearing tillers influenced the yield of straw, producing higher yield at 40 kg K$_2$O/ha (44.87 qtl/ha) and 80 kg K$_2$O/ha (45.93 qtl/ha).

The length of earhead was also not significantly influenced due to the application of Potash. But longer earheads were produced by the plots applied with 40 kg K$_2$O/ha. Again the weight of 1000-grain was higher in respect of 40 and 80 kg K$_2$O/ha. The longer earhead as well as higher 1000-grain weight attributed higher yield due to the level 40 kg K$_2$O/ha followed by 80 kg
KgC/ha. Beyond this further application of additional dose of Potashic fertilizer proved uneconomic. Stewart (1947), Panse et al. (1947), Roychoudhury and Dutta (1964) reported increase in the yield due to Potash application. On the contrary, Mathur (1971), Mann and Sharma (1971) reported no beneficial effect due to Potash application.

From the results it could be concluded that though the yield was increased due to Potash application at 40 and 80 Kg K$_2$C/ha, it was very poor in comparison to the yield due to Nitrogen. Mahapatra et al. (1973) reported that the response to Potash was very low. However, 63.60 kg K$_2$C/ha level was expected to give maximum yield of grain (24.13 qtl/ha), whereas the 25.6 Kg K$_2$C/ha was expected to give maximum net profit.

Effect of Calcium:

Different levels of Calcium could not produce significant response in respect of growth of the vegetative characters. But 40 and 60 kg CaO/ha showed a tendency to increase the plant height as well as number of tillers per plant. This effect might be due to the stimulation of development of root system of crop. Banford (1931) reported that wheat failed to develop lateral roots in absence of Calcium.

Yield attributing characters, such as, length of earhead, number of ear, and weight of 1000-grain were also found increasing at 40 and 80 kg CaO/ha, but the results are not significant statistically. Anonymous (1959) reported that at 1/2 ton CaO per acre rate the difference was not significant. However, whatever
little effect in increasing the different characters rendered by Calcium at 40 and 80 kg CaC/ha, is ultimately reflected in the yield of grain and straw. This might be due to the fact that application of lime reduces the H-ions concentration, as a matter of fact the concentration of OH-ion increases. This decreased the solubility of iron, aluminium and Manganese which increased the availability of essential elements; as a result the yield increases. Raheja (1966) also reported similar findings.

Again, the soil, in which the crop was grown was slightly acidic. Therefore, higher doses of Calcium applied might be injurious to the soil as well as crop, resulting in reduced yield of grain. The results led to infer that the benefit occurring from lime application was very poor. However, the maximum yield of grain could be expected from 12.80 kg CaC/ha as was indicated by the response curve study.

Effect of N, P, K and Zn:

The vegetative characters, such as, plant height, number of tillers and number of leaves per plant were influenced significantly in both the years due to the application NPK, NP and NK levels irrespective of Zinc. The difference among them were very less in case of height of plant. This might be due to the fact that the effects of Phosphorus and Potash were very low in comparison to Nitrogen effect leaving negligible differential effect. Therefore Nitrogen irrespective of other elements in its combinations, acted vigorously resulting taller plants, with increased number of tillers and leaves. The more leaves increased
photosynthetic activity which affected the yield of grain. The effect of Zinc in respect of vegetative characters was not significant.

Number of ear per plant and number of grain per plant were maximum at NPK and minimum at PK level. However, Zinc showed increasing effect over NPK. The length of earhead was also influenced by different combinations with Nitrogen. Longer earhead carried more number of grain. Again, the weight of grain per plant was increased as a result of the application of NPK, NP, NK, while crop treated with PK resulted in the reduced number of grain, and weight of grain. This might be due to the absence of Nitrogen. But higher weight of 1000-grain, though not significant, was recorded by PK. In other words PK produced lesser but heavier grain. NPK, NP, NK could not produce heavier grain than PK.

The yield of grain was highly influenced by different combinations of which NPK produced maximum and PK minimum. While NK and NP were almost at par with each other. This increase in yield was due to the increased weight of grain, number of grain and number of ears per plant. However, the yield of grain produced by NPK at 120-80-60 kg/ha was higher than NP at 120-80 kg/ha, while NP produced better yield than NK at 120-80 kg/ha. Similar observations have been reported by Singh et al. (1969), Mann and Sharma (1971), and Mahapatra et al. (1973) reported increased yield due to NPK fertilizers.

Zinc could not produce significantly higher yields over N, P, K combinations. However, an increasing trend was noticed in yield over NPK and NP. This might be due to the increasing
effect of Zinc in respect of weight of grain per plant. Thus, it showed its necessity in wheat cultivation. Mann and Sharma (1971) reported higher yields of wheat over NPK due to application of Zinc.

The yield of straw was found higher at NPK followed by NP and NK, while PK registered minimum yield. Increased straw yield resulted from more number of tiller per plant. Reddi (1972) also reported highest yield of straw and grain due to NPK.

Dry weight of root was found higher in case of NPK and NP than NK and PK. This showed that the growth and development of root was increased with NPK and NP which resulted in more weight of root. Moreover, Nitrogen increased the dry matter content of the plant with Phosphate application. The absence of P from NPK resulted reduction in dry matter but the absence of Nitrogen proved harmful to the plant in respect of dry matter content. As a result PK reduced the dry weight of root to the minimum and NK produced lesser dry weight of root than NP. Sing and Verma (1965), Roy (1965), Singh and Sharma (1968) reported increased dry matter content with the increased levels of Nitrogen. While Misra et al. (1972) reported significant increase in dry root when Nitrogen applied with Phosphate. Bondale (1967) also reported increased dry matter with Phosphate application. Here Zinc could not produce significant effect on dry weight of root.

Protein content of the grain was also influenced by NPK, NP and NK. NPK produced highest percentage of protein. While the difference in between NP, NK was negligible. But the grain of the crop treated with PK exhibited minimum percentage of protein. The increase in protein content might be due to the effect of Nitrogen as its absence in PK resulted minimum quantity of protein. Increased protein content due to Nitrogen application have been
reported by several workers, such as, Bains (1953), Chandnani et al. (1960), Arakeri et al. (1961), Modgal and Das (1963), Choudhury and Bains (1967) and many others.

The reduction in protein content at PK in absence of Nitrogen might be due to the effect of Phosphatic fertilizer too. Similar decrease in protein content due to Phosphatic fertilizer was recorded by many workers, such as, Eck et al (1963), Gupta and Das (1954), William and Smith (1954), and Shrivastava et al. (1955),

In a conclusion it could be inferred that the effect of Nitrogen limited the yield and protein content of the crop. Again the effect of P as well as K was low. Therefore, due to the absence of Nitrogen, or due to lower effects of P and K the level PK could not produce satisfactory result in respect of all observations under study. On the other hand Zinc showed an increasing tendency in case of yield of grain. In respect of protein content of grain the effect of Zinc was not satisfactory.

Correlation and path analysis:

An examination of the correlation coefficients from both the years revealed that weight of grains per plant, number of ears per plant, number of grains per plant, and length of earhead were the four most important yield attributes which exerted the greatest positive influence upon grain yield. Among these, the character - weight of grain is merely an intermediary step and is determined by the variables number of grains, number of ears,
and length of earhead. The path coefficient analysis indicated a somewhat different picture than the correlation analysis in case of number of grains, length of earhead and 1000-grain weight. From the two year's path analysis data it was evident that it was the number of ears per plant which was found consistent, positive and highly significant in influencing the yield of grain. Number of grains though showed a positive significant correlation, the path analysis in the first year, unlike second year, revealed that the direct effect was negative. In case of length of earhead, the direct effect was found to be negative in both the years, but its correlation was positive and significant. Therefore, it might be presumed that significant positive correlation was due to its high indirect effect via other variables. Similar findings were reported by Shrivastava and Singh (1971).

Again, the significant negative correlation between thousand grain weight and grain yield gave a misleading impression that this important yield attribute had an adverse effect on grain yield; but the path analysis of second year's data revealed that the direct effect of thousand grain weight was positive. Similar findings have also been obtained by Dewey and Lu (1959), and Ramanujan and Rai (1963), who worked with crested wheat grass and *Brassica campestris* respectively. According to these workers, the apparent conflict between the two analysis arises largely from the fact that two methods measure different things. Whereas correlation simply measures mutual association without regard to causation, the path analysis measures their
relative importance. Therefore, it may be concluded that besides weight of grain per plant it was the number of ears which exerted greatest positive influence directly and indirectly upon the grain yield. Similar results were also reported by Shrivastava et al. (1971). The variables length of earhead and number of grains, though not consistent, showed positive influence upon the grain yield.