REVIEW OF LITERATURE

The review of literature embracing the relevant references in relation to the present investigation is presented below.

2.1. Sowing Dates.

Chandnani (1953), while examining the effect of sowing date on the yield of wheat observed 15th November (other dates of sowing being 20th October and 10th December) as the optimum sowing date, producing the maximum yield. The yield reduced when sown earlier or later. It was also clear that wheat crop when sown either early or late would need higher doses of Nitrogen than the wheat crop sown during the optimum period. Anant Rao et al. (1956) and Jain et al. (1963) reported that the optimum period of sowing the wheat crop was between 30th October and 20th November.

Rai (1966) summarising results from the field trial, conducted during Rabi season of 1961-62 reported that significantly higher grain and straw yield (19.29 q/ha and 39.90 q/ha) were obtained when the wheat crop was sown on 7th November and 23rd October respectively.

Mehta and Mathur (1972) conducting experiments with six dates of sowing (20th, 30th October, 10th November, 20th November, 30th November and 10th December) and six seed rates.
at Mandore in Rajasthan, during 1962-63 and 1963-64, observed that the optimum period of sowing of wheat was between 30th October and 20th November, but the 10th December sowing gave the lowest yield because of hot and dessicating winds in the month of February-March at the milk stage. In earlier sowing on 20th October the grain yield was reduced due to frost injury to the ear heads in the month of January.

After the introduction of Dwarf wheats in India agronomists all over the country took up the task of evolving agronomical schedule for these wheats. Results of some of the experiments are presented below.

Mathur (1966), Tomar and Mathur (1966), Rai (1966), Mahanta (1967), Narang et al. (1968) and Gupta et al. (1968) observed the first fortnight of November to be the optimum time of sowing wheat.

Experiments conducted at the Indian Agricultural Research Institute (I.A.R.I.), New Delhi, with a design to determine the optimum sowing time revealed that most of the dwarf wheats gave high yield when sown after the first week of November. Early sowing resulted in poor tillering, very early heading and lower yield due to high temperature. Sowing of dwarf wheats should, therefore, be adjusted when the mean daily temperature is about 20°C. The optimum date of sowing for 'Kalyan Sona', 'S-331' and 'Safed Lerma' was the first fortnight of November, while second fortnight was the optimum sowing time for 'Sharbati Sonara' and 'Sonalika' (Anon, 1969). Warsi et al. (1969) in their studies at Kanpur observed early days of
November as optimum time for wheat sowing.

Agarwal et al. (1971) conducting Cultural experiments on wheat with five sowing dates (Nov-4, Nov-18, Dec-2, Dec-16 and Dec-31) and three levels of Nitrogen (80, 120 and 160 kg per hectare) at Haryana Agricultural University, Hisar reported that November 18 was the best sowing date. Application of 120 kg N/ha proved to be the best under normal sowing but, 160 kg N/ha was best under late sown conditions. Chandrasekhariah et al. (1971) from Mysore reported higher grain yield of Mexican wheat with sowing on 16th October. Increased yields of 36, 13 and 29 per cent were obtained with the sowing on 16th October over that sown on 16th September, 30th September and 1st November respectively.

Dubey and Lal (1971) experimenting on wheat in 1967-68 to study the behaviour of S-308 under different sowing dates (30th October, 15th November, 30th November and 15th December) reported that the crop sown by 15th November took normal preflowering growth period, while the crop sown by 30th October shortened its preflowering period due to higher atmospheric temperature. When the crop was sown by 30th November or 15th December, its flowering period was shortened considerably, because by the time it came into flowering stage, the atmospheric temperature went higher. The shortening/preflowering as well as flowering period was probably responsible for the reduction in yield in either early or late sown crops.

Agrawal et al. (1972) conducting experiment with six dates of sowing on three varieties of wheat (Sharbati Sonara,
Sonalika and Kalyan Sona) at Kanpur, reported that in the year 1967-68, 31st October recorded the highest yield of 35.80 q/ha, whereas in 1968-69, 10th November sowing yielded 38.98 q/ha, which was significantly higher than the earlier sowing, but in 1969-70, 5th November produced 43.81 q/ha, which was the highest yield observed. Poor yield registered under the first date (26th October) of sowing was attributed to reduced number of grains per ear and 1000-grain weight. Summarising the results these workers concluded that the optimum time of sowing dwarf wheat varieties under Kanpur conditions fell between 31st October to 10th November when atmospheric temperature reached about 30°C.

2.2. Variety.

Kohli (1966) reported from Uniform Regional Trial that the yield potential of 'Kalyan Sona' was higher than that of 'Sonalika' and 'Sonara-64'. Similar observations were made by Bhardwaj (1967) and Kohli and Anderson (1967). Similarly in Madhya Pradesh, Gupta (1969) found 'S-227' (Kalyan Sona) superior in yield to 'S-308' (Sonalika) and 'Sonara-64'.

Kohli (1969) from the Co-ordinated Trials conducted in Penninsular India reported that 'Safed Lerma' proved superior in yield to the other varieties, the snag being unattractive colour of the grains. Contrary-wise, Singh (1969) from Demonstration Trial in U. P. reported highest yield from 'Kalyan Sona' (5508 kg/ha) followed by 'Sonalika' (5339 kg/ha), 'Sharbati Sonara' (5021 kg/ha), 'Chhoti Lerma' (4934 kg/ha) and 'Safed Lerma' (5021 kg/ha).
Shrivastava (1970) from the results of the All India Co-ordinated Trials in 1968-69 reported that Kalyan Sona recorded the highest yield under medium maturity period, whereas 'Sonalika' was the best under short season conditions. But under mild and short winter conditions that prevail in Southern and Eastern India, 'Safed Lerma' scored the highest yield. Sandhu and Gill (1972) reported from Ludhiana in Punjab that 'Kalyan Sona' produced on an average 41.2 per cent more yield than '0-306'.

Swaminathan et al. (1972) working for two years (1968-69 and 1969-70) on seven varieties of wheat at I. A. R. I., New Delhi, reported that out of the varieties 'Sonalika' sown on 25th December significantly out yielded all the other varieties yielding as high as 40.27 and 45.70 q/ha in the two seasons respectively. 'Kalyan Sona' yielded lower than 'Sonalika' and triple dwarf, but yielded higher than 'Sharbati Sonara'. Agrawal et al. (1972) reported highest yield in 'Kalyan Sona', but it was at par with 'Sonalika' and both proved superior to 'Sharbati Sonara' in yield.

2.3. Micronutrient Studies.

With the introduction of Mexican wheat research on micronutrients was acutely felt. Accordingly eight centres under the Co-ordinated Research Scheme, one centre under Ad-hoc Research Scheme and a few voluntary research workers are collaborating in the micronutrient investigations (Konwar, 1972). Works done on this line before and after the introduction of Mexican wheat are reviewed as hereunder.
Sadaphal and Das (1966) worked with Cu, Mn, Zn and Mg as sulphate at the rate of 5, 10, 5 and 10 lbs per acre respectively to study their effect on the quality and yield of wheat. These workers reported greater yield when zinc was applied as foliar spray than added to the soil. Sadaphal and Das (1961) reported from I.A.R.I. that soil application of 5 lbs Zn per acre through foliar spray increased the yield of wheat by 16.1 per cent. Koradi and Seth (1964) obtained 15.2 per cent more yield of wheat grain by the use of 10 kg Zn sulphate per hectare through soil or 2.5 kg per hectare through foliar sprays.

Asana et al. (1964) found an increase of 300 lbs per acre in the yield of wheat grain through application of 20 lbs. boron per acre at I.A.R.I. Koradi and Seth (1964) reported higher yield of wheat grain through the use of boron (11.2 kg/ha).

Ghose et al. (1964) reported that in a field trial and also in pot experiment, increased yield was obtained by the application of N, P, K, but further increase in yields of wheat oat and potatoes were recorded by the application of Zn and S along with N, P, K fertilizers.

Deal and Angel (1965) studying the effect of vegetative growth observed no effect on growth rate of wheat when 5-10 lbs. of zinc per acre were applied, whereas the same dose of zinc per acre stimulated root growth.

Konwar (1966) studying the effect of micronutrients on the yield of different crops reported that 6 lbs. of zinc sulphate per acre showed significant increase in yield of wheat in Punjab.
Mehrotra et al. (1967) summarising the results obtained from field experiments conducted on wheat at different places in U. P. from 1953 to 1957 observed some beneficial effects of zinc, boron and copper in certain areas of the State. Application of 2 lbs. Boron per acre as Borax increased the yield at Kalyanpur (Kanpur). Use of copper gave beneficial responses at Atarra (Banda), Kalai (Aligarh) and Kanpur. Zinc was found to be useful at Atarra and Kaloi.

Gupta and Manglik (1967) reported that the application of certain micronutrients (Mo, Mn, Zn, Cu and Spdrtin) significantly improved the generally observed lack of response of rainfed wheat to N, P, K. in years of scanty winter rainfall throughout, in high rainfall season whence wheat responded well to N, P, K., no such additional effect of micronutrients was obtained under the agro-climatic conditions of Tarai (U.P.), while Kurchani et al. (1968) working with Cu, Zn, Mn, B applied at the rate of 11.25 kg per hectare on the yield of wheat revealed that the wheat crop lacked significant response to any of the micro-nutrients applied either in soil or foliage.

In the year 1969, Indian Council of Agricultural Research (I.C.A.R.) reported that except Zinc, which was found to be deficient in some pockets, dwarf wheat crop did not show deficiency of other micronutrients in India. On Zinc deficient soils, Zinc sulphate at 10-15 kg per hectare was recommended to be applied before sowing (Anon, 1969).

Konwar (1969) studying the micronutrient content of Indian soils observed that total content of Zinc, Boron and Molybdenum were 10-300 ppm, 7-630 ppm and 0.2-5.0 ppm respectively.
This worker recommended the application of Boron as Borax (5-20 kg/ha) Zinc as Zinc sulphate (10-40 kg/ha) and Molybdenum as Sodium molybdate (15-500 gm/ha) in the form of 0.2 p.c. Borax, 0.5 p.c. Zinc sulphate + 0.25 p.c. Lime, and 0.05 p.c. Sodium molybdate spray application respectively.

Sharma (1969) reported that high yielding varieties showed higher intake of plant nutrients including Zinc. Zinc deficiency in wheat crop was first observed in the Rabi season of 1968. Work has shown that Zinc sulphate (5 kg) mixed with lime (2.5 kg) in one thousand litres of water to cover one applied hectare should be as soon as stunted patches and Zinc deficient plants appeared in wheat field.

Patnaik (1970) studying micronutrient removal by wheat crop reported that for 7 tons of grain yield per hectare wheat crop removed 218, 383 and 13.0 gm/ha Boron, Zinc and Molybdenum respectively. Studying the micronutrient susceptibility of wheat varieties Patnaik further reported that in terms of degree of susceptibility 'Kalyan Sona' showed very high, 'Safed Lerma' high and 'Sonalika' moderate to Zinc. In case of Boron 'Kalyan Sona' was moderate, while 'Safed Lerma' and 'Sonalika' were low in degree of susceptibility.

Mann and Sharma (1971) from a number of field experiments conducted in Jammu and Kashmir State under Co-ordinated Agronomic Programme Experiments recorded a variable response of different micronutrients to various crops at different locations. Results of three experiments conducted on wheat indicated a consistent and significantly higher yields due to Zn application over N.P.K. Highest response of about 9 qtl/ha
was obtained by application of Zinc during 1969-70 (NPK - 5778 kg and Zinc + NPK 6687 kg/ha).

Dhillon et al. (1971) conducting experiments at Ludhiana during 1965-67 reported that 10 kg Zinc/ha caused a significant increase in yield and number of grain/ear. Molybdenum and Boron failed to show any significant increase in yield and grain per ear.

Konwar (1972) reported from the Combined Workshop on micronutrients and soil test crop correlation schemes that in case of saline alkali soils, Zinc deficiency was very marked and the effect of application of Zinc sulphate in increasing the yield of wheat was very spectacular. In case of normal soil slow application of Zinc sulphate as a prophylactic dose would be essential. Experiments on cultivators' field in Ludhiana district revealed that wheat yield increased from 0.4 to 17.4 qtl/ha with the application of 5 parts per million (5 ppm) of Zinc (about 20 kg zinc sulphate). Randhawa and Dev (1972) also reported increase in grain yield with the application of 5 ppm Zinc sulphate.

Patil et al. (1972) by applying Zinc and Boron as foliar spray through 1560 litres of water per hectare and Molybdenum foliar spray through 1125 litres of water per hectare at the rate of 4.71 kg ZnSO₄/ha 3.14 kg Borax/ha and 210 gm Sod. molybdate /ha found effective in increasing wheat yield. Single foliar spray of 210 gm Sod. molybdate, one month after germination of seeds, was found highly effective in increasing wheat yield at Bhanwat Tabuka Seed Farm, Maharashtra, giving additional yield of 304 kg/ha. At Tharsa, Zinc and Boron were found
effective in increasing wheat yield giving additional yield of 59 kg/ha and 52 kg/ha respectively.

2.4. Effect of Nitrogen Fertilization on Yield of Wheat.

During the last few decades considerable volume of work has been carried out by different workers to find out the effect of different doses of Nitrogenous fertilizer on yield of wheat crop.

Holmes and Tahir (1957) working on winter wheat under three spacings, three levels of fertilizers with three time of applications reported that a progressive increase in nitrogen fertilizer (Am. sulphate) per acre proportionately increased the grain and straw yield of all populations. There was also an increase in the number of tillers and in the percentage of tiller producing ears. The nitrogen content of the grain increased with nitrogen levels.

Widdowson and Cooke (1958) working to study the effect of nitrogen fertilization in spring Barley and wheat reported that 0.5 N/acre may be sufficient for maximum yields. Jain et al. (1959) reported significant increase in yield of wheat due to nitrogen application.

Raheja et al. (1960) while reviewing the works done throughout India concluded that 22.4 kg Nitrogen per hectare under irrigated conditions in the form of Ammonium sulphate gave additional yield of 3.08 quintals on an average, but under unirrigated condition the same dose gave an additional yield of 2.14 quintals only. Arakeri et al. (1961) recorded 14.25 p.c.
grains yield of wheat with a dose of 44.91 kg/ hectare.

Gautam (1961) reported increase of the grain yield of wheat by 12.5 and 29.0 p.c. due to two nitrogen levels of 33.63 and 67.26 kg/ha over control, the corresponding increase in straw yields were of the order of 27.6 and 44.8 p.c. respectively. Verma (1961), Patel and Patel (1961), Relwani (1962), Mehta and Jaisinghani (1962a, 1962b), Relwani and Ghose (1963), Jain et al. (1963), Kala et al. (1963), Jain et al. (1963a, 1963b), Gandhi et al. (1964), Gandhi and Mathur (1964), Mathur et al. (1964), Panse and Khanna (1964), Pathak (1964) and Singh et al. (1964) observed significant effect of Nitrogen on wheat yield.

Singh et al. (1964) working with 0, 33.6, 67.2 and 100 kg Nitrogen per hectare found that the yield increased upto 67.2 kg level, but there was decrease in yield when Nitrogen level reached 100 kg per hectare. Singh and Verma (1965) also observed a similar trend with 0, 22.5, 45.0, 67.5, 90.0 and 112.5 kg N/ha. They obtained highest yield with 45 kg N/ha, and further increase in nitrogen level reduced the yield. Increase in wheat yield was also reported by several other workers, such as, Singh (1965), Pathak (1965), Singh and Prasad (1966), Sharma and Rae (1966), Singh and Tiwari (1966), Gautam et al. (1966), Sexhon et al. (1967), Joshi et al. (1967, Singh and Verma (1967), Singh et al. (1968) and Singh and Govil (1968).

Mehta and Sekhawat (1972) studying fertilizer response on wheat with four levels (0, 33.6, 67.2 and 100.8 kg/ha) of Nitrogen as Ammonium sulphate in Rajasthan during Rabi season 1962-63 to 1964-65 reported that increasing levels of nitrogen
increased grain yield. The highest and significant returns obtained was 44.0 p.c. over control by the application of 100.8 kg N/ha.

After the introduction of dwarf wheats in India, agronomists all over the country took up the task of evolving agronomical schedule for these wheats. Results of some of the manurial experiments are revealed hereunder.

Borlaug (1957) reported from the Co-operative Mexican Agricultural Research Programme organized in 1943 that experiments on Nitrogen, Phosphorus and Potash requirements of soils where wheat was grown and supplementary experiments revealed that in almost every area a deficiency of Nitrogen limited wheat yields. In older areas Nitrogen must be applied in large quantities upto 120 lbs. per acre in order to obtain yields 45 to 60 bushels per acre.

Experiments conducted at the I.A.R.I., New Delhi to find out the comparative yield potential of two Mexican (Sonara-63 and Mayo-64) wheat varieties and Indian wheat variety (MP 824) under high levels of Nitrogen fertilization (40, 80, 120 kg N/ha) revealed that Sonora 63 gave the highest yield of 45.6 qtl/ha, which was significantly higher than Mayo 64 (36.5 qtl/ha) and MP 824 (27.9 qtl/ha) (Gandhi and Roy, 1964). Swaminathan (1965) recorded the highest yield from Sonora-64 to the tune of 6.45 tonnes/ha with the application of 100 kg N/ha. From the same station Bhardwaj et al. (1966), reported the results of an experiment conducted to compare the response of tall and dwarf wheat varieties to varying levels of Nitrogen fertilization (0, 40, 80, 120, 160 and 200 kg/ha). The tall variety
el wheat C-306 gave significant response to N application only up to 80 kg N/ha. In contrast, the yields of dwarf Sonora-64 and the semidwarf Lerma Rojo increased with increase in Nitrogen levels up to 160 and 200 kg N/ha respectively.

Sharma et al. (1966) pursued carefully the results of grain yield of these wheat varieties as influenced by Nitrogen level and plant population. The results revealed that the yield of Sonora 64 decreased with higher plant population at 120 kg N/ha dose in both the years. However, the yield of Lerma Rojo increased with increasing dose of nitrogen and plant population. Grain yield of both Sonora 64 and NP 876 was maximum at 120 kg Nitrogen levels with different plant population.

Sharma and Singh (1966) tried three Mexican varieties (Sonora-63, Sonora-64 and Lerma Rojo) and three Indian varieties (C-306, NP 876 and NP 887) at four levels of Nitrogen (0, 45, 90 and 135 kg/ha) with a basal application of 67 kg P_2O_5 and 45 kg K_2O in all plots. It was seen that average grain yield increased up to 90 kg dose in case of Mexican dwarf wheats, however, in case of Indian varieties, it increased only up to 45 kg N/ha. The maximum yield (4774 kg/ha) was obtained from Lerma Rojo when it was fertilized with 90 kg N/ha.

In National Demonstrations (1965-66) average yield per hectare for Mexican dwarf wheats was 4183 kg while for Indian tall, it was only 3046 kg/ha (Singh and Karg, 1967). An yield of 68 quintal per hectare of S-227 from farmers' field was also reported by Swaminathan (1967).

Wheat Agronomists Workshop held at the I.A.R.I., New Delhi in 1967 recommended application of 100-120 kg Nitrogen
per hectare for maximum economic returns from the dwarf wheats. It was further recommended that if wheat follows legumes, green manuring, or fallow this dose might be reduced to about 80 kg Nitrogen per hectare.

Bharadwaj and Wright (1967) observed that the yield curves for Sonora 64 and Lerma Rojo continued to increase with nitrogen levels all the way up to 200 kg N/ha, but the tall varieties showed little yield increase beyond 80 kg N/ha. Saxena (1967) reported that S-227 failed to show any positive response to nitrogen application, beyond 100 kg N/ha, while the local variety could show a response only up to 60 kg N/ha.

Swaminathan (1967) reported that the varieties and management practices were known which would help the farmers to obtain 40, 60 or 80 quintals of yield in a hectare. The worker further pointed out that with the release of triple dwarf currently under development, the yield potential would go up to 100 to 200 quintals per hectare with a dose of even 250 kg N/ha.

Muthuswamy (1967) stated that in future triple dwarf (45 cm. to 60 cm. high) would be able to stand more than 160 kg of N/ha, and still not lodge. They are expected to bear existing grain yields with a good margin.

Singh and Sharma (1969) working on dwarf and tall wheat varieties with an increase in the level of nitrogen from 0 to 160 kg/ha at 40 kg interval reported that both 80 and 120 kg N/ha gave maximum and almost similar yields. The highest dose of 160 kg N/ha depressed the yield significantly. Increase in
yield upto 120 kg N/ha was also confirmed by Singh et al. (1969). Sinha and Roy (1969) also reported similar increasing yield upto 120 kg/ha which was followed by 160 kg N/ha, 80 kg N/ha and 40 kg N/ha in order.

In 1969, Indian Council of Agricultural Research (I.C.A.R.), New Delhi, reported that unlike the tall wheats which lodge severely at nitrogen rates higher than 60-80 kg per hectare, the dwarf wheats show profitable response to nitrogen application upto 120 kg N/ha. The optimum dose of nitrogen for the dwarf wheat is 100-120 kg N/ha (Anon, 1969).

Gill et al. (1971) conducting an experiment on wheat with different levels (0, 40, 80, 120, 160, 200 kg N/ha) of nitrogen as ammonium sulphate reported from Punjab that yield of wheat increased upto the highest dose.

Singh et al. (1971) reported that grain yield per plant and its attributes were not effected appreciably by the nitrogen levels, however, N$_2$ (80, 120, 160 kg N/ha - N$_1$, N$_2$, N$_3$ respectively) showed better performance in both the years. N$_2$ was the best level for grain production of dwarf wheats in Agra region. Straw yield per hectare increased with increasing doses of Nitrogen. N$_2$ treatment was found to be optimum for straw production of dwarf wheats.

Mathur et al. (1971) reported from an experiment conducted at Govt. Agricultural Farm, Rajasthan, during Rabi 1966-67 that application of 80, 120 and 160 kg N/ha produced 36.4, 54.4 and 61.0 per cent more yield over that of 40 kg N/ha respectively. No significant differences was observed between
the effects of 120 and 160 kg N/ha, but both were significantly superior to 80 kg N/ha.

Sinha (1971) reviewing the references to important nutrient element Nitrogen reached the conclusion that response of wheat to nitrogen on soils of low fertility was almost universal. Various workers used nitrogen from low doses to very high doses with different varieties and reported the optimum doses ranging from 20 to 160 kg N per ha under different agro-climatic conditions. The doses used by different workers were 22.5 (Chandnani, 1954), 33 (Rao et al., 1957), 45 (Nelson, 1960), 56 to 67 (Prashar and Singh, 1963), 90 (Chandnani and Kavitkar, 1955), 100 to 120 (Ehardwaj, 1967) and 120 to 160 (Sharma et al., 1970) kg N per ha. However, the optimum dose of nitrogen have recently been worked out to be 100 to 160 kg N per hectare.

Misra and Singh (1972) conducting some experiments to measure the relative efficiencies of N fertilizers reported that amoniacal fertilizers applied at 80 kg/ha were more efficient in increasing grain yield. Sandhu and Gill (1972) also reported that the application of nitrogen increased the grain yield and the doses higher than 120 kg per hectare proved harmful.

Agrawal et al. (1972) reported that during the years 1967-68 the dose of 120 kg N/ma gave significantly highest yield. The dose of 60 kg N/ha also gave significantly higher yield over control.
2.5. Effect of Nitrogen on Yield Attributing Characters of Wheat.

Ranjan and Bajpai (1958) found that the length/inflorescence was greater in plants which received higher doses of Nitrogen. Prasad (1962) observed that nitrogen fertilization in general significantly increased the length of earhead. While working at Sabour, Singh (1968) reported that the ear length of S-227 was increased from 0 to 120 kg N/ha but beyond 120 kg N/ha there was a reduction in the ear length. Singh and Sharma (1969) also reported increase in length of earhead with the application of 120 kg N/ha.

There is diversity of opinion regarding the effect of nitrogen in increasing number of grain per earhead. Bajpai (1951), Raheja and Misra (1955), Mann (1956), Prasad (1962) and Singh (1964) reported that increase in the level of Nitrogen increased the number of grains per earhead, while working at Sabour with dwarf wheat, Sharma (1968) obtained significant increase in number of grains per earhead at 60, 100 and 140 kg N/ha but Singh (1968) could obtain increase only up to 120 kg N/ha and beyond this, there was a reduction in the grain number. Sandhu and Gill (1971) from Punjab reported that the application of nitrogen significantly increased grain number per ear. Similar results were also observed by Gill and Batra (1968) and Saxena et al. (1968). In the variety S-227, Singh and Sharma (1969) confirmed it.

Sandhu and Gill (1972) conducting experiments at Students' Farm, P.A.U. reported that application of nitrogen increased
grain weight per ear. These results are in conformity with those of Gill and Batra (1968) and Saxena et al. (1968).

Saxena et al. (1965) observed maximum weight of 1000 grain when 83.5 kg N and 45 kg P₂O₅ per hectare were applied. Singh reported (1968) that 1000 grain weight of wheat was highest with 84 kg N/ha in the case of Nf⁷¹. Experiments conducted at Sabour with dwarf wheat, S-308 Sharma (1968) found the highest 1000 grain weight at 140 kg N/ha. Saxena et al. (1968), Gill and Batra (1968), and Singh and Sharma (1969), Sandhu and Gill (1971), Agrawal et al. (1972) all reported increase in 1000 grain weight due to nitrogen application. Singh and Gupta (1969) are also in conformity with it.

Holmes and Tahir (1957) working on winter wheat under three levels of nitrogenous fertilizers reported an increase in the per cent of tiller producing ears with the increase in nitrogen levels. Singh and Gupta (1969) conducting experiments at J. V. College Farm, Meerut concluded that on the basis of average for the 3 years the number of heads per plant tended to increase with the increase in level of nitrogen.


2.6.1. Plant Height.

Raheja et al. (1960) reported small increase in height of wheat plants due to application of nitrogen fertilizers at the rate of 22.4 and 44.8 kg/ha. Saxena et al. (1965) working with 28, 30, 58, 90 and 84.09 kg N/ha, reported an increase in plant height due to increased doses of Nitrogen. Choudhury...
and Bains (1967) also obtained significant increase in plant height due to increasing rates of Nitrogen application.

Singh and Govil (1968) observed that the height of wheat plant increased with increased doses of Nitrogen from 0, 20, 40 and 60 kg N/ha but the rate of increase was very small. While conducting experiments on dwarf wheat S-308, Sharma (1968) reported increase in height at 60, 100 and 140 kg N/ha. Increased plant height was also reported by Sekhon et al. (1968), Sandhu and Gill (1972) and Misra et al. (1972).

2.6.2. Number of Tillers.

Singh (1952) reported from Lucknow that early application of nitrogen up to 112 kg/ha increased the number of tillers in wheat. Raheja and Misra (1955) observed that application of nitrogen at the rates of 22.5 and 45 kg/ha not only increased tillering but helped in greater survival of shoots. Rai (1961), Prasad (1962), and Garg and Jain (1963) also reported from I.A.R.I., New Delhi, that nitrogen application increased the number of tillers per plant.

Roy (1966) reported in case of dwarf wheats that with suitable varieties and better agronomic practices it would be possible to achieve even higher yields than those recorded in such trials under report. He further suggested that for this purpose, use of early semi dwarf and dwarf varieties of wheat with synchronous tillering habit might open up a new vista in production under such condition. Sharma (1968) while working at Sabour with dwarf wheat found that there was a significant increase in the tillering at 60, 100 and 140 kg N/ha. Similar
results were also reported by Sekhon et al. (1968), Misra et al. (1972) and Sandhu and Gill (1972).

2.6.3. Dry Matter Accumulation.

Sen and Pai (1953) reported from New Delhi, that whole plant of wheat differed considerably in dry weights at different fertility levels. Mann (1957) reported that under all the nutrient treatment dry matter accumulation was higher. Malkani et al. (1959) also found that early application of nitrogen at the rate of 22.5 and 45 kg/ha increased the shoot and root ratios as well as top weight of mother shoot.

Singh and Verma (1965) working on response of wheat varieties at different levels of Nitrogen found that the total dry matter increased with an increase in the levels of nitrogen. The highest response was obtained with 45 kg N/ha.

With dwarf wheats Roy (1965) found a progressive and significant increase in the dry matter content with higher levels of Nitrogen up to 120 kg/ha. Sharma (1968) reported from Sabour that there was significant increase in dry weight of S-308 at 60, 100, 140 kg N/ha, respectively. From the same station, Singh (1968) obtained significant increase in dry matter production of S-227 at 40, 80 and 120 kg N/ha, but beyond 120 kg N/ha, there was a significant reduction. Misra et al. (1972) also reported that 80 kg N/ha when applied with 60 kg P₂O₅/ha there was a significant increase in dry weight.
2.7. Effect of Nitrogen on Grain Quality.

There is a general belief that nitrogen enrich wheat grain with higher percentage of protein (Black et al., 1946 and Williams and Smith, 1954). On the other hand, Smith, Das and Mathur (1951), and Sen and Pal (1953) reported that the protein content of wheat was not significantly influenced by Nitrogen application. Chandrashekhara *et al.* (1953) reported that low protein content and low yield were more correlated than high protein and high yield.

Bains (1953) found that the application of Nitrogen at the rate of 67.2 kg/ha increased the protein content of wheat grain by about 10.5 per cent. Sen and Pal (1953) did not observed correlative increase of protein content of wheat grain under different fertility levels. On the contrary Chandnani and Kavitkar (1955) obtained an increase in the nitrogen content of wheat grain with rise in Nitrogen level. Application of 89.82 kg N/ha gave the highest nitrogen content in wheat grain.

Chandnani *et al.* (1960) and Austin and Miri (1961) found that protein content of wheat was increased on account of Nitrogen fertilization. Increase in protein content of wheat with increasing doses of nitrogen have also been observed by Arakeri *et al.* (1961), Rai (1961), Prasad (1962) and Sasulki and Paul (1963). Modgal and Das (1963) recommended 67.5 kg N/ha for maximum protein and high protein accumulation in the grain.

Working at the I.A.R.I., New Delhi, Austin *et al.* (1964) observed that 22.45 kg N/ha did not increase significantly the protein content, where as, the increase due to 44.91 and 67.37 kg N/ha were significant.
Swaminathan (1965) found that when fertilized with 100 : 50 : 50 kg N.P.K. per hectare both Sonora 64 and Lerma Rojo had high protein (14.6 p.c.) and gluten (13.2 p.c.) content. Further Varughese and Swaminathan (1967) reported that Sharbati Sonora had more protein content (16.5 p.c.) than Sonora-64 (14.4 p.c.). The gluten percentage in the former was 12.3 p.c. while the later had 8.7 p.c. only.

Choudhury and Bains (1967) found that seed of an unfer­tilized wheat crop had a protein content of 10.3 p.c. This protein content increased to 12.6 p.c. when crop received 112 kg N/ha. Sharma (1968) and Singh (1968) got appreciable increase in protein content at higher doses of Nitrogen.

Juarez (1955), Therne (1955), Meselev et al. (1956), Sadaphal and Das (1956), Finney et al. (1957), Seth et al. (1960) Almeida and Santos (1962), Webst (1963), Schlesinger (1964), Hechst (1964), Ewald (1965), Greene (1965), Stepanov (1965) and Sinha (1971), all these workers reported that late application of nitrogen was found to be beneficial mainly from the quality point of view, and excess of nitrogen was carried over until filling and ripening time and then stored in kernels, producing an increase in the protein content.

2.6. Effect of Phosphorus on Yield of Wheat.

The results of experiments on Phosphorus fertilization of wheat conducted prior to 1947 have not led to any fruitful generalization regarding the use of this nutrient (Stewart, 1947, Panse et al., 1947).
Roy Choudhury (1952) discussing the role of chemical fertilizers in relation to the soil productivity in India, reported that in case of irrigated wheat a combination of artificial nitrogen and phosphorus gave the highest increase in yield.

Yates et al. (1953), while summarising the results of field experiments conducted in India with superphosphate calculated the standardised response of 90 kg of wheat grain or 22.5 kg P₂O₅/ha which was equivalent to 6.6 kg of grain yield per kg of P₂O₅. Agarwal et al. (1953) reported an increase of 31 per cent in the yield with 67.5 kg P₂O₅ per hectare, the average response per kg of P₂O₅ worked out to be 8.2 kg of grain. The application of 67.5 kg P₂O₅/ha through superphosphate was reported to increase the yield of wheat by 38.61 per cent over control, at coimbatore, while in Madhya Pradesh poor response was obtained. At Aligarh, in U.P., application of 20.1 kg P₂O₅/ha increased the yield by 15.6 per cent (Anon, 1953).

Ghose (1954) summarising the results of a large number of field experiments, stated that the general response to phosphate fertilisation alone in India had been poor and that the returns were of little importance.

In the agronomic trials on wheat from the year 1953 to 1956, under the Indo-U.S. (T.C.M.) Fertilizer Use Project, it was found that ammonium phosphate gave generally better yield response than superphosphate and nitrophosphate. Chandnani (1954), Chela (1956), Motwani (1958), Relwani (1959) and Patel and Patel (1961) tried various doses of phosphate alone and in combination with nitrogen and obtained distinctly higher response due to
phosphate application. Agarwal et al. (1955) observed only small increase in yield with phosphate in the Bindelkhand Tract of U.P.

Shrivastava et al. (1955), Acharya et al. (1958) and Jain et al. (1959) all reported that the application of phosphatic fertilizers has generally been accepted to increase the yield of wheat in almost all types of soils. The results of simple and complex experiment conducted in Community Project under the 'Soil Fertility and Fertilizer Use Project' revealed that at almost all the centres the phosphate applications increased the yield of wheat (Anon, 1960). But Arakeri et al. (1961) recorded a depression in yield with 45 kg $P_2O_5$ per hectare.

Singh (1961) conducting experiment in phosphorus deficient soil (with total and available $P_2O_5$ content of 0.09 and 0.005 per cent respectively as against 0.132 and 0.013 for phosphate rich soil) economical average responses were obtained. The dose of phosphorus used in this experiment was 67.5 and 134 kg $P_2O_5$ per hectare. Sharma (1962) obtained increases of 8 to 17 per cent under $P_{33}$ and $P_{67}$ over control for grain yield.

Jain et al. (1963) reported increase in wheat yield to the tune of 49 kg and 98 kg per hectare with 22.5 and 45 kg $P_2O_5$ per hectare, respectively. Konwar and Meelu (1963) also found similar response.

Under dry farming condition of Vidiha in Madhya Pradesh, Pathak (1964) observed significant increase in yield of 168 and 217 kg over control, when phosphorus was applied at the rate of 22.5 and 45 kg per hectare respectively.
Singh and Prasad (1966) reported that phosphatic fertilization caused a significant increase in grain yield per plant. Sharma and Rae (1966) also found a significant increase in yield from P₀ to P₃₃.₆₃ and from P₃₃.₆₃ to P₆₇.₂₆. The average increase under P₃₃.₆₃ and P₆₇.₂₆ over P₀ worked out to be 8 and 17 per cent for grain and 8 to 16 percent for straw.

Bondale (1967) found the highest average yield 15.97 quintals per hectare due to application of 134 kg P₂O₅ per hectare. From I.A.R.I., New Delhi, Bharadwaj and Wright (1967) reported that Sonora 64 gave 38.5 quintals per hectare with P₀ whereas yield with 50 kg P₂O₅ per hectare was 44.6 q/ha i.e., an increase of 610 kg/ha over control. Sinha and Roy (1969) also reported increase yield of wheat due to phosphate application. But Singh and Gupta (1969) reported that the overall grain yield response to P was not significant but its application increased straw yield by 11 per cent.

Mathur et al. (1971) reported that application of 40 and 80 kg P₂O₅/ha gave 18.1 and 46.2 per cent more yield respectively over control. Yield obtained with 80 kg P₂O₅/ha was also significantly higher than 40 kg P₂O₅/ha.

Singh (1972) reported from I.A.R.I., New Delhi, that under All India Co-ordinated Wheat Improvement Project during Habi 1970-71, the yield due to phosphorus application was much higher but the response was limited to the lower doses only. The economic optima for phosphate application was 69.9 kg/ha. Misra and Singh (1972) also found significant increase in yield when nitrogenous fertilizers were applied with 60 kg P₂O₅/ha.
Dtakur et al. (1978) conducting a replicated trial at the Wheat Research Station, Powerkeda, M.P., during 1970-71 to study the residual effect of phosphorus on grain yield of wheat applied to Soyabean crop at the rate of 0, 40, 80, 120 and 160 kg/ha through single super phosphate reported that wheat yield increased significantly at the rate of 23.78, 27.17, 31.27, 32.70, 34.85 q/ha corresponding to the 0, 40, 80, 120 and 160 kg P$_2$O$_5$/ha although at higher levels the increase in wheat yield was a matter of magnitude.

2.9. Effect of Phosphorus on Yield Attributing Characters of Wheat.

Singh (1964) reported that phosphate application increased the 1000-grain weight but it failed to produce any significant effect on ear characters of plant. Mallik et al. (1965) found that increase in phosphate dose from 0 to 33.6 kg per hectare had no effect on panicle length, but the number of spikelets, number of grain per panicle and 1000-grain weight increased significantly due to each successive dose.

Singh and Prasad (1966) observed significant increase in number of grains per ear at different doses of phosphate (0, 24, 48 and 72 kg P$_2$O$_5$/ha) but the 1000 grain weight remained unchanged. Singh (1967) reported that phosphate application increased significantly the number of grains per ear at different levels (22.4, 44.8 and 67.2 kg P$_2$O$_5$/ha) but the increase in other yield characters was not significant. Bondale (1967) observed that, the number of grains per ear head, length of ear
head and 1000-grain weight showed significant rise at different phosphate doses, whereas Singh and Govil (1966) did not find any significant difference in yield contributing factors of wheat at increasing levels of phosphate.

Report from I.C.A.R., New Delhi, led to infer an imperative need of soil test for determining the phosphorus status of the soil. If deficient in phosphorus, 50 - 60 kg P\textsubscript{2}O\textsubscript{5}/ha should be placed about 5 cm below the seed at the time of sowing (Anon, 1969).

Sinha and Roy (1969) summarised that band placement of phosphate being at par with drilling behind plough exerted maximum beneficial effect in increasing the yield of wheat by influencing favourably the yield attributes, viz, number of ear bearing tillers per plant, number of grains per ear and thousand-grains weight.

2.10. Effect of Phosphorus on Growth of Wheat.

2.10.1. Height of Plant.

Pan and Kunz (1938), Russell (1939), Grantham (1947) and Luginbille and McNeal (1954) observed positive response of phosphate application to the growth and development of wheat characterised by increase in height.

Motwani (1958) reported that nitrogen and phosphate applied at the rate of 22.4 and 44.3 kg per hectare respectively helped in increasing the height of wheat plants. Mallik et al. (1965) found similar result of 33.6 kg P\textsubscript{2}O\textsubscript{5}/ha with 22.4 and 44.3 kg of nitrogen per hectare, respectively.
Saxena et al. (1965) observed increase in plant height when 45 kg $P_2O_5$/ha was applied along with 88.3 kg N/ha. Increase in height of wheat plant with phosphate application was also reported by Singh and Prasad (1966) and Bondale (1967). But Singh and Govil (1968) did not find any significant increase in height at 20, 40 and 60 kg $P_2O_5$/ha.

2.10.2. Number of Tillers.

Singh (1964) after studying the results of several experiments at B. R. College, Bichpuri (Agra) found that increase in grain yield per plant due to phosphate application appeared to be due to increase in the ear bearing tillers. Pathak (1965) reported that the number of ear bearing tillers were significantly increased at 22.5 kg N and 45 kg $P_2O_5$/ha respectively. Saxena et al. (1965) working at Nawabganj (Uttar Pradesh) observed an increase in tiller number due to combination of 74.10 kg N and 49.85 kg $P_2O_5$/ha which gave the best result. Several workers like Mallik et al. (1965), Singh and Prasad (1966) and Bondale (1967) reported increase in number of tillers due to phosphate application.

2.10.3. Dry Matter Accumulation.

Singh (1961) found that phosphate (134 and 268 kg/ha) with or without 45 kg nitrogen increased the dry matter to the tune of 7.31 and 5.1 kg respectively.

Bolaria and Mann (1964) reported that the dry weight of roots increased up to the heading stage and then decreased at maturity. The decrease in dry weight was less in treatments
including nitrogen alone or in combination with phosphorus. Bondale (1967) working with 22.5, 45, 67.5, 89, 112 and 134 kg P₂O₅/ha found significant increase in dry matter.

2.11. Effect of Phosphorus on Grain Quality.

Regarding the influence of phosphatic fertilization on the quality of wheat, Chandrasekharan et al. (1953), Williams and Smith (1954), Shrivastava et al. (1955) reported increase in P₂O₅ content but decrease in protein content of grain.

Hunt et al. (1950) and Bains (1953) reported increase of thiamine and nicotinic acid content of wheat due to application of phosphatic fertilizers.

Johnson (1953), Ayidoni et al. (1954) and Fedorov et al. (1955) observed improvement in winter hardiness of wheat due to application of phosphates.

Gupta and Das (1954) reported that the application of phosphatic fertilizers generally reduced the protein content of grain. Raheja and Misra found that dressing of phosphate either increased or decreased the nitrogen content of grain irrespective of the presence or absence of nitrogen.

Gupta and Das (1956) and Pal (1966) found increase of thiamine and nicotinic acid content of wheat due to application of phosphatic fertilizer alone or in combination with other fertilizers. Singh and Prasad (1966) observed that P fertilization tended to decrease grain protein content. The maximum protein content (10.65 p.c.) was recorded in grain from unphosphated plot. This decrease to 10.29 per cent in grain was found
in plots treated with 72 kg/ha.

Bhargava and Metiramani (1967) observed the application of super phosphate decreased the nitrogen and phosphate content at tillering and harvesting stages of growth, but it increased the calcium content at all stages of growth and magnesium content at tillering and grain.

Mehretra et al. (1967) found that application of phosphate increased the nitrogen uptake.

2.12. Effect of Potash.

In India until quite recently, the experiments conducted with potash have been few, as it was believed that Indian soils were well rich with potassium. Earlier experimentation on potash indicated no response in most of the Indian soils (Roychoudhury and Datta, 1964). Potash has not been given a fair trial in India in the past experiments (Vidyanathan, 1933). None of the experiments in any part of India had indicated any effect, beneficial or harmful, by the application of potassium (Sethi et al., 1953). The results of the experiments conducted till 1931 showed negative response to potash on alluvial, laterite and red soils (Roychoudhury and Datta, 1964).

Pense et al. (1947) summarizing the results of 806 manurial trials conducted on wheat observed that under irrigated conditions, a response of 3 to 5 lb. for every lb. of K₂O obtained under potash application at the rate of 30 to 40 lb. per acre in presence of nitrogen and phosphate at Sangor and Nagpur. At Nagpur Labhandi and Powerkhaeda, an average response of 10.0 lb. per
lb. N and 3.3 lb. K$_2$O was obtained for application of saltpetre equivalent to 20 to 0 lb. nitrogen per acre. This response, which was greater than the response to nitrogen alone, supported the observation regarding the useful effect of supplementing potash to nitrogen in the parts of black soil tracts.

Stewart (1947) in his report stated that there were sporadic references on positive response of potash manuring and increases in yield. He cited the cases of wheat responses at Nagpur, Labhandi and Powarkheda in Madhya Pradesh and Patna in Bihar.

Panse et al. (1947) conducting two trials at Patna observed that in presence of 30 lb. N and 20 lb. P$_2$O$_5$ per acre, the doses of 5, 10, 15, 25 and 30 lb. K$_2$O per acre gave the response of 21.2, 24.2, 11.8, 6.4, 3.6 and 5.8 respectively of wheat for every lb. of K$_2$O used.

Experiments conducted during 1948-49 and 1949-50 at the Indian Agricultural Research Institute, New Delhi showed no response to 40 lb. K$_2$O when applied over the dose of 40 lb. nitrogen and 60 lb. P$_2$O$_5$ per acre (Raheja and Misra, 1955).

Simple trials, conducted recently on cultivators' field in 16 districts in Bihar State, have showed an average response of 2.5 md. per acre for every 40 lb. K$_2$O applied in presence of 40 lb. N and 40 lb. P$_2$O$_5$ per acre (Mukherjee and Sinha, 1953-1954).

During 1954-55 and 1955-56, 303 Simple Trials on cultivators' field were conducted in 16 Community Project Centres under Fertilizer Use Project Scheme. Under irrigated conditions,
manuring of wheat with 20 and 40 lb. K$_2$O per acre proved most profitable in Delhi State, while with 20 at Pisanganj, Raisingnagar, and Summerpur (Rajasthan). Application of 40 lb. K$_2$O per acre also gave profitable response in Nawanahar and Milekheri (Punjab) and in Rajasthan. Under unirrigated conditions at M.P. response to doses of potash were not profitable.

Raheja et al. (1958) summarizing the works done throughout India reported that there are areas where application of potash in conjunction with the optimum dose of N and P increased the yield of wheat.

Roychoudhury and Datta (1964) reviewing the phosphorus and potassium status of Indian soils reported that the effect of potash has always been found to be better in combination with nitrogen though earlier results indicated no response of the Indian soils.

Mathur et al. (1971) reported from Rajasthan that application of 0 to 40 kg K$_2$O per hectare produced 2286.4 and 2255.4 kg per hectare respectively. So potash had no beneficial effect on the yield of wheat crop. Man and Sharma (1971) also reported similar findings. Mahapatra et al. (1973) reported that the response to K was very low.

2.13. Effect of Calcium.

Calcium is an important secondary nutrient for growth and development of crop. Moreover as soil corrector either in acidic or saline condition the importance of calcium is highlighted. In addition, calcium improves microbial activity and
symbiotic fixation in acid soil. In saline condition calcium as gypsum is found very useful for reclamation. However, works on this element were very few up to the early part of the present century. Sethi et al. (1953) made a very interesting statement which runs: 'of the large number of manurial experiments conducted in India, a majority deal with nitrogen, the most important nutrient. Experiments with phosphorus and potassium are relatively fewer and those with calcium (lime) are extremely few.'

Calcium forms an essential component of plant tissues. The action of lime is partly physical and partly chemical, setting free the dominant plant food. It also corrects soil reaction. Calcium flocculates the soil and develops a porous structure which is conducive to entrance of oxygen and oxidation processes in the soil. Lee (1946) summarizing the effects of lime to plant growth observed that the importance of lime to plant growth is mere as a liberator of plant nutrient from the soil complex than as nutrient to the plant.

Rakeja and Misra (1955) working on wheat with calcium at 0, 5, 10 and 16 lb. per acre level reported that lime exhibited depressing effect almost throughout the crop growing season. It showed least influence on number of grain and number of shoot. Of course at harvest it showed a slight increase in respect of shoot number.

Anonymous (1959) working under Fertilizer Use Project in acid soils of Shimoga and Ponnampet to study the effect of lime reported that out of three levels (1/2 ton/acre, 1 ton/acre,
2 ton/acre) the response to lime at 1 ton per acre was very substantial at Ponnampet. At 1/2 ton per acre rate the difference was not significant. At Shimoga, significant response were obtained at both the levels, the response increasing with increased level of lime.

Raheja (1966) reported that calcium has a profound influence on the development of root system of crops. In wheat lateral roots fail to develop (Benford, 1931). Calcium as calcium pectate is an essential constituent of the middle lamella of the cell wall.


Singh et al. (1969) from 22 demonstrations in 11 districts of U.P. using fixed dose of 120 kg N/ha in combination with phosphorus and potash at the rate of 60 kg and 40 kg per hectare respectively reported that yields at all locations were found to be higher with the combinations of nutrients than the nitrogen alone. The yield under the treatment with nitrogen and phosphorus (NP) was higher than joint effect of nitrogen and potash. The yield with nitrogen, phosphorus and potash (NPK) was higher in all locations as compared with nitrogen and phosphorus (NP), and nitrogen and potash (NK).

Mann and Sharma (1971) from experiment under Model Agronomic Experiments (M.A.E.) Scheme on three varieties of wheat at different levels of NPK (N - 0, 60, 120 kg/ha; P and K - 0, 30, 60 kg/ha) reported that dwarf varieties responded well producing maximum (70.15 q/ha) at 120 kg N/ha, while yield
of local variety depressed at 120 kg/ha. Phosphorus levels also produced increased yield with increasing levels (50.70, 53.15, 61.30 q/ha at 0, 30, 60 kg P₂O₅/ha). But potash application did not show any increase in yield in case of S-308 variety.

Mathur et al. (1971) reported that application of 120 kg N/ha and 80 kg P₂O₅/ha was found to be the optimum for dwarf wheat under Rajasthan canal conditions on areas recently brought under irrigated farming.

Randhawa and Dev (1972) conducting experiments for evaluating relationship between fertilizer consumption and yield of wheat in nine different districts of Punjab reported that with an optimum dose of 120 kg N/ha dwarf varieties of wheat gave good to high responses. Each kg of nitrogen with 120 kg/ha dose resulted in increasing yield of wheat by 8 kg grain and each kg P₂O₅ with a dose of 60 kg in conjunction with N increased yield by 13 kg grain. However the response obtained with phosphate application were generally of lower order than those of nitrogen.

Sankara Reddi (1972) conducting trials to find out the feasibility of raising a wheat crop at S. V. Agricultural College Farm, Tirupati reported that application of 120 kg N/ha was found to give the highest yield of grain and straw, as a result of 120 kg N, 60 kg P₂O₅ and 60 kg K₂O/ha was adequate.

Meelu et al. (1973) conducting 121 experiments during 1970-72 at Hoshiarpur district of Punjab reported that application of 25 kg and 50 kg N₂/ha increased the wheat yield by 3.14 q/ha and 5.24 q/ha respectively. 50 kg N in combination with 25 kg P₂O₅/ha doubled the yield over control by 8.44 q/ha. The
application of 25 kg K₂O/ha increased the yield further but the increase was very slight, only about 0.76 q/ha.

Mahapatra et al. (1973) from simple fertilizer trials under the All India Co-ordinated Agronomic Experiments Scheme during 1969-70 and 1971-72 reported that response to phosphorus application over a basal dose of nitrogen was higher than when applied alone. Response to 25 kg N/ha + P 25 kg/ha was higher than the responses to N 50 kg/ha alone. They concluded that the profit obtained was maximum with application of balanced fertilizers 50 kg N₂ + 25 kg P₂O₅ + 25 kg K₂O. The profit obtained with application of 25 kg N₂ + 25 kg P₂O₅ per hectare were more than that obtained with application of 50 kg N/ha alone.

2.15. Correlation Study.

Dewey and Lu (1959) established importance of seed size, fertility and plant size as determiners of seed yield of standard crested wheat grass by using the methods of Path Co-efficient. Singh and Pratap (1967) obtained a very high correlation of yield with length of ear. Jha and Ram (1968) found a highly significant correlation between yield and length of ear heads and number of ear bearing tillers.

Shrivastava et al. (1971) observed that correlation between grain yield and all yield attributing characters except thousand-kernel weight was positive and highly significant which indicated that increase in any one of them increased the yield. He further revealed that number of spikelet per spike had positive and the maximum association with grain yield, i.e., had a
maximum direct and indirect effect on grain yield of wheat S-227. Length of spike, number of kernels per spikelet, number of effective tillers per clump, and thousand kernel weight ranked 2nd, 3rd, 4th and 5th respectively. The association of thousand kernel weight was however, practically negligible.